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THE HOMOLOGIES OF THE FINS OF FISHES.

BY E. D. COPE.

I. THE RELATION OF FINS TO LEGS.

ALTHOUGH it is well established that the paired fins of fishes are, as a whole, homologous with the limbs of the higher vertebrates, and although many naturalists have given their views upon the homologies of the respective parts, the subject is yet involved in considerable doubt; and, as stated by Prof. Huxley in 1871, the basal and radial supports of the fins themselves can only be identified in the most general way with the limb-bones or cartilages of other vertebrata.

The doctrine that the vertebrate limbs are modified ribs was advocated, to a varying extent and with modifications, by Maclise [1] (1832) and Oken [2] (1843); while Owen [3] (1848) regarded them as diverging appendages attached to ribs, with a shoulder-girdle of axial origin. Professor Goodsir [4] (1857) considered the limbs as homologous with the epipleural spines of fishes, and external to the proper visceral wall of the body. Professor Humphrey [5] (1871) concluded that the vertical fins were of bifold origin, since

[1] Todd's Encyclopædia, Vol. IV., p. 70. Fig. 490.

[2] Lehrbuch der Natur-Philosophie, p. 330.

[3] Archetype and Homologies of the Vertebrate Skeleton.

[4] *Edinburgh New Philosophical Journal*, Vol. V., 1857, p. 178.

[5] *Cambridge Journal of Anat. and Physiol.*, Vol. V. (Second Series, Vol IV.), p. 58, Plate II.

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the dorsal and ventral mid-lines of the body are formed by the junction of the bifold *laminæ dorsales* and *ventrales.* He considered that the pectorals and ventrals were certain portions of the lower azygos fins, prevented from uniting by the interposed body-cavity. Maclise had previously regarded the distal portions of the limbs as corresponding with the azygos fins. In

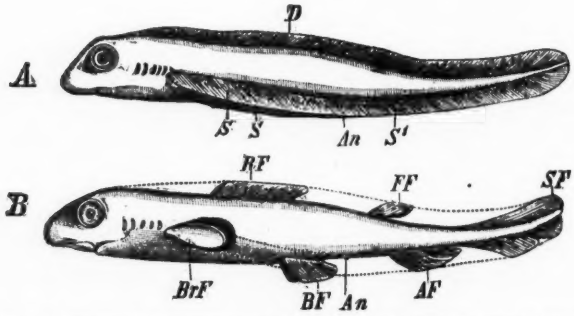


FIG. 1.—Diagrammatic representation of primitive and derivative types of lateral and median fins. *A*, primative condition, fins continuous; *B*, derivative condition, fins distinct and specialized; *D*, dorsal fins; *Br F*, pectoral; *B F*, ventral: *A F*, anal; *S F*, caudal; *R F*, dorsal; *F F*, second dorsal fin; from Wiedersheim.

1876 Balfour[6] described the development of the limbs of Elasmobranchs as "special developments of a continuous ridge on each side, precisely like the ridges of epiblast which form the rudiments of the unpaired fins," and concludes from this "that the limbs are remnants of continuous lateral fins." The primitive folds persist in the vertical and caudal fins, while the paired fins represent portions of such folds (Fig. 1).

As regards their intimate structure, those of the Elasmobranchs and Polypterus occupy in some sort a middle term between those of the Teleostomata and those of the Dipnoi. In order, therefore, to trace out the homologies between the segments of the paired fins of the Teleostomata and those of the limbs of the Reptilia, the parts must be traced in lineal order through the following classes or sub-classes: Reptilia, Batrachia, Dipnoi, Elasmobranchii, Teleostomata. (Figs. 2, 3.) Naturalists dis-

[6] Ibid., Vol. XI., Part I., p. 132.

agree in the interpretation of the homologies of these parts, but if the view enunciated by Balfour of the origin and development of the paired limbs is the correct one, it is possible that a homology can be traced along the downward scale of limb-development from the Batrachia on the one hand, and the Teleostomata on the other, to the ancestral type of the Ichthyotomi of the Carboniferous, the oldest limb type known.

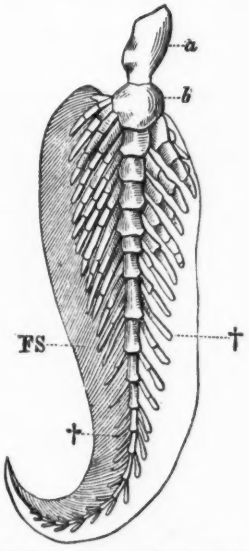


FIG. 2.—*Neoceratodus forsterii*, pectoral, fins, unibasal type; *a b*, axial elements; †, radials; *F S*, fin-rays; from Wiedersheim.

Dr. Gill[7] traces out the relationship of the members of the shoulder-girdle in the Dipnoi with those of the Batrachia as follows: The proximal element of the anterior limb of the Dipnoan is the homologue of the humerus. In the Urodela the humerus is articulated chiefly with the coracoid; therefore, the element of the Dipnoan shoulder-girdle with which the humerus is articulated is the coracoid, unless evidence to the contrary can be produced. The scapula in the Batrachia is entirely or almost excluded from the glenoid foramen, therefore the corresponding element in the Dipnoi must be the scapula. The element of the Dipnoan shoulder-girdle continuous downwards from the scapula, and to which the coracoid is closely applied, is named by Gill the ectocoracoid. Each half of the shouldergirdle is surmounted by an element which is named the supraclavicle by Gegenbaur, the suprascapula by Gunther, the scapula by Owen; and this is in turn connected with the skull by another element, the posttemporal of Parker and Gill, who justly observe that there is an *à priori* improbability against the homology with the scapula of any part having a ligamentary connection with the humerus-bearing element.

[7] Arrangement of the Families of Fishes, Nov., 1872. Smithsonian Misc. Col., Vol. XI.

As far as his argument applies to the Dipnoan pectoral Gill, may be safely followed, except in his view of the element abutting upon the occiput, which he regards as having intimate relations with the skull, and probably originating from it. In tracing back the homologies of the parts of the Dipnoan to those of the teleostome shoulder-girdle, Dr. Gill is less cogent, and the nomenclature adopted by Gegenbaur[8] appears preferable. The latter author figures the right half of the shoulder-girdle and the thoracic fin of a teleostome fish (Gadus). Here there is no humerus

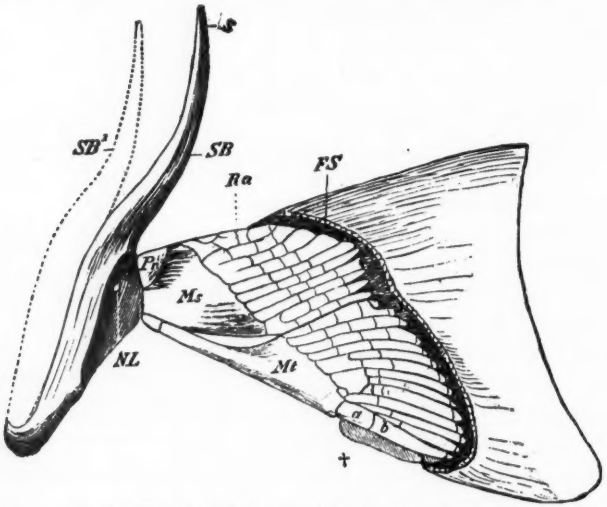


FIG. 3.—*Heptanchus griseus*, left pectoral fin, pluribasal type. *SB*, scapular arch; *NL*, foramen; *Pr*, propterygium; *Ms*, mesopterygium; *Mt*, metapterygium; *a b*, exis of metapterygium; *Ra*, basilars; *FS*, fin-rays; from Wiedersheim.

recognizable as such, but that the so-called "carpals" or basilars of the fin are regarded as representing it, is evident from the fact that the bone to which they are attached is styled the coracoid, and that which abuts against it the scapula. The element corresponding to the "proscapula" of Gill, and formed, according to him, of the united scapula and ectocoracoid, is by Gegenbaur called the clavicle, which is attached to the supraclavicle

[8] Elements of Comparative Anatomy, Second Edition, p. 475, 1877.

above. The bone connected with the skull is, as has been said before, named the posttemporal by Parker. The clavicle of Gegenbaur is the coracoid of Owen,[9] while his scapula is Owen's ulna, and his coracoid the radius. As Gill remarks, Owen first sought to determine an ulna and radius, and then identified the other bones from their relations to it. (Figs. 3 and 4.)

But, even though the terms used by Gegenbaur be adopted as representing most nearly the correspondences between the parts of the shoulder-girdle of the Dipnoi and Stapedifera on the one hand, and those of the Teleostomata, Crossopterygia, Podopterygia, and Elasmobranchs on the other, an exact homology is not yet positively assured. Hence Gill has subsequently termed Gegenbaur's scapula hypercoracoid, and his coracoid the hyopocoracoid.

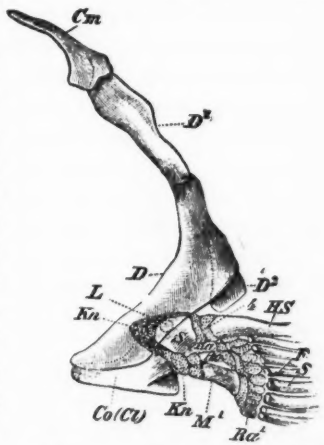


FIG 4.—*Salmo fario*, left shoulder-girdle; *Cm*, posttemporal; D^1, epiclavicle; *D*, clavicle; D^2, postclavicle; *S*, scapula; *Co*(*Cl*), coracoid; *Ra*, basilars; *L*, scapular foramen; *HS*, *FS*, fin-rays.

In the ventral fins the process of concrescence is carried to a considerable extent in Polypterus and the Chrondrostei, and farther still in Amia, Lepidosteus and the Teleostomata, which agree in the possession of a single large elongated element proximal to the basilars in each ventral. To this base are attached four long basilar rays in Polypterus, nine in *Accipenser brevirostrum*, and three minute ossicles in the Teleostomata. The elongated supporting bone is styled by Thacher a pubis, and Wiedersheim has recently shown that it is a part of the pelvis, and, being preacetabular, is the homologue of the pubis.[10] The conclusion that can be arrived at from a study of both the pectoral and ventral fins is that the limbs of all air-breathing mammals or Stapedifera (possessed of a stapes) form a group

[9] Comp. Anat. and Physiol. of Vertebrates, Vol. I., p. 106.

[10] *Anatomischer Anzeiger*, 1889, IV.

more nearly related to each other than any of them are to any other vertebrate groups; and that the archipterygian form is to be found in the unibasal pectoral and ventral fins of the Ichthyotomi, the unibasal Crossopterygia, and the Dipnoi. (Plate XIV.)

These are substantially the conclusions arrived at by Mr. Thacher,[11] who names the group composed of the Dipnoi and higher vertebrates the Choanata, from their possession of "choanæ," or posterior nares opening behind the lips. But the Ichthyotomi and the unibasal Crossopterygia were not known to him.

According to Gegenbaur,[13] the archipterygium, or primitive form of limb from which all the limbs of the Gnathostomes, or vertebrates with lower jaws, have been developed, is to be found in its parent form in the limb of Ceratodus, which consists of an elongated, tapering, many-jointed rod, bearing upon each side a series of rays. In a previous paper,[14] the fin of Protopterus, bearing on the outer side only a series of rays, had been taken as the type. In the second edition of his "Grundriss," Gegenbaur adheres to the idea enunciated in his later article,[15] and identifies the metapterygium of Acanthias and other Elasmobranchs, plus one only out of the many rays, with the main stem of the fin of Ceratodus; while the propterygium, mesopterygium, and all the

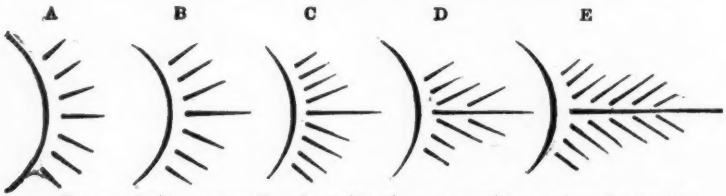


FIG. 5.—Archipterygium *E*, and transitional stages to actinopterygium *A*, according to Gegenbaur; from Wiedersheim.

other rays of the Elasmobranch fin are regarded as developments from the lateral rays of a Ceratodus-like fin. By a further slipping off of the rays from the main- or stem-row, Gegenbaur derives the many-rayed fins of the Teleostomata from those of the Elasmobranchii, which he has previously asserted to be derived

[11] Ventral Fins of Ganoids. Trans. Conn. Acad., IV., 1877, p. 242.
[13] Anatomy of Vertebrated Animals, p. 36.
[14] *Jena. Zeitschrift*, Bd. VII., Hft. 2, pp. 131-141.
[15] Ibid., Bd. V., Hft., 4.

from those of the Dipnoi. Huxley,[16] in 1876, concurred in this view of the archipterygium, but regarded the main stem as passing through the fifth finger instead of through the thumb, an arrangement which Gegenbaur has adopted in his second edition. (Fig. 4.)

As has been shown, the view propounded by Mr. Thacher in 1877,[17] and also independently worked out by Prof. Balfour, namely, that the paired fins of all vertebrates are formed from a continuous lateral fold, corresponding to the median fold from which the vertical fins of fishes are derived, is that which is supported by the greater weight of evidence, and is now most generally adopted. It is strongly supported by the extinct genus of Acanthodean fishes, Climatius, in which a series of spines extends on each side of the abdomen from the pectoral to the ventral fins. And these spines are said to be similar to those which support the anterior border of these fins. The evidence of paleontology is, however, equally in favor of the unibasal paired fin (archipterygium) as the ancestral form, as it characterized the oldest Elasmobranchii (Ichthyotomi) and Crossopterygia, while the pluribasal type is of later age in both divisions of fishes. But it may have been derived from a continuous fin, as suggested by Climatius.

If this view be followed, the Dipnoan paired fins must be regarded as a derivative from the paired fins of the Ichthyotomi, which must still be looked upon as the form from which the limbs of the Stapedifera or air-breathing vertebrates have been derived. Baur believes that the latter have been constructed from a simple axis like that of Lepidosiren by a process of budding, and not by rearrangement of the branches of a fin of the Ceratodus type. The Teleostomata, although specialized in many ways, stand on one side of the upward line that leads to the reptiles, birds, and mammals, and their paired fins retain much of the primitive character.

2. THE RELATIONS OF FINS TO EACH OTHER.

The paired limbs of the higher vertebrates appear, at first sight, exceedingly unlike the fins of fishes, yet it has long been

[16] Proc. Zoöl. Soc. Lon., 1876, Pt. 1, on *Ceratodus forsterii*.
[17] Proc. Conn. Acad., Vol. II., p. 281.

believed by naturalists that the pectoral and ventral fins of the latter are the homologues respectively of the fore and hind limbs of the former. But between the paired fins of fishes and the median or vertical fins there are also resemblances which warrant a suspicion of their origin from similar primitive structures, nsomuch that it is now believed by many that the median fins are derivatives from a primitive continuous vertical fold, while the paired fins are the specialized remainders of primitively continuous lateral folds.

Cope, writing in 1870,[18] remarks upon the analogy that exists, on the one hand, between the succession in the type of the pectoral fin, commencing with the simple axis of the Dipnoi, and passing to the axis with lateral appendages or radii, seen in Selache, and, on the other hand, the succession by which the median fins of Polypterus pass from rays with a jointed, forked extremity continuous with the base (in the caudal part of the series) to the structure that obtains in the dorsal pinnules, which consist of a strong spinous ray from the posterior face of which a number of soft rays project. He also regarded the segments which support the dorsal and anal rays in ancient fishes and Elasmobranchs as homologous with those which support the rays of the pectoral and ventral fins, and calls them all basilars, and, in a later essay, [19] baseosts. He showed that the baseosts experience the same reduction with time in all the fins, being obliterated in the dorsal, anal, and ventral fins in nearly all modern Teleostomata, and being reduced to four or fewer in the pectoral fin in most of the same.

A most carefully worked out contribution to this portion of the developmental history of vertebrate appendages is that of J. K. Thacher,[20] who converts the analogy noticed by Cope into a homodynamism, and regards the Dipnoan paired fins, not as maintained by Gegenbaur,[21] as the primitive form or archiptery-

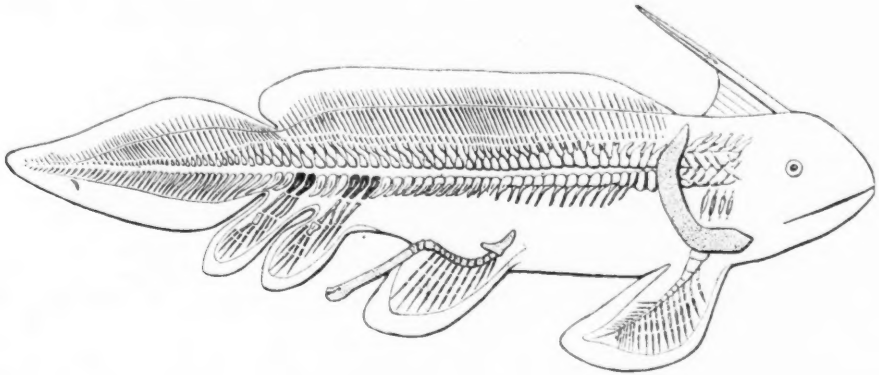
[18] Contribution to the Ichthyology of the Lesser Antilles. Amer. Philos. Society, XIV., 446-483, 1870.

[19] AMERICAN NATURALIST, 1887, p. 1016.

[20] Median and Paired Fins. Trans. Conn. Acad., Vol. III., 1877.

[21] *Jena. Zeitschrift*, Bd. V., Hft. 4. Gegenbaur über den Gliedmaassen der Wirbelthiere im Allgemeinen und der Hintergleidmaassen der Selachier in besonders. May, 1870.

PLATE XIV.



XENACANTHUS DECHENI.

gium, but as a derivative from the primitive series of parallel rays of the lateral folds.

The conclusions of this writer respecting the median fins are as follows: The primordial median fin-rays are derived from a series of parallel chondroid rods, which grow up in the median fold totally independent of the cartilaginous arches above and below the notochord. The earliest representatives of these parts, as the quadrate markings at the base of the median fin in Branchiostoma, and the fin-rays of Myxine and Petromyzon, are much more numerous than the vertebræ opposite them. Therefore, neither are median fin-rays derived from neural spines, nor neural spines from primordial fin-rays, but neural spines are formed by the dorsad prolongation and union of the neurapophyses of the vertebræ.

This statement, which is supported by the structure, not only of the lower fishes mentioned above, but that of the Elasmobranchs, which have from 2 to 3.5 fin-rays to one vertebra, and that of Acipenser, is in opposition to the earlier opinion of Gegenbaur,[22] who asserts that the primordial fin-rays, in their simplest form, are mere prolongations of the neural spines.

The primitive fishes have been shown by Cope to sustain the view of Gegenbaur. The invariable equality of number between the vertebræ and the actinophores (see section 3, below) in Dipnoi is supposed by Thacher to be the result of the entire loss of the primordial median fin-rays, the long and segmented supports of the median fold in Lepidosiren, Ceratodus, etc., being simply elongated neural spines. This view is not sustained by paleontology.

Carrying his argument onwards to the lateral or paired fins, Mr. Thacher shows that the ventral and dorsal fins of *Mustelus canis* agree in every respect save the separateness of the basal elements in the latter, and their coalescence in the former, and argues that this certain amount of similarity warrants us in inferring an earlier state when the similarity was greater. The similarity between the structure of the anal and ventral fins of Acipenser is evident from an inspection of the figures. The theory put forward by Thacher, is, therefore, as follows: As the dorsal and anal fins

[22] Grundriss der Vergleichenden Anatomie, 1873, p. 488.

were specializations of the median folds of Branchiostoma, so the paired fins were specializations of the two lateral folds which are the homologues of the Wolffian ridges, in embryos of higher forms. Rods formed in both median and lateral folds. In the latter, these became at least twice segmented, the orad ones were prolonged inwards, more or less concresence took place, and the cartilages spreading, met below in the middle line, and later, extending dorsad, completed the limb girdle. Gegenbaur, in the later edition of his "Grundriss," has modified his views respecting the nature of the primordial fin-rays, since he says :[23] "Supporting organs, formed from the integument, are connected with the parts thus formed by the vertebral column (superior and inferior arches), and they are continued into the caudal fin. In the Selachii the fin-rays are formed by the so-called horny filaments, and in the Ganoidei and Teleostei by ossifications."

The same eminent anatomist, who has aided so greatly in establishing the relationship between the various parts of the simple paired fins of the Dipnoi, and those of the air-breathing vertebrates (Stapedifera, Thacher), refuses to concede the homodynamism of the median and paired fins, but adheres in the later edition of the "Grundriss" to the theory propounded by him in 1872,[24] namely: their derivation from the branchial arches, by the articulation of the simple lateral rays set upon those arches to the central ray, which gradually assumes increased length, and becomes an axis. In this way a fin like that of Ceratodus might be produced.

The views of Mr. Thacher are, however, supported by the independent but later observations of Balfour,[25] who found that in the embryo dogfish the lateral fins have precisely the same mode of origin as the dorsal median fin, arising "as special developments of a continuous ridge on each side, precisely like the ridges of epiblast which form the rudiments of the unpaired fins."

[23] Elements of Comparative Anatomy, by Carl Gegenbaur, 1877. (Translated by F. Jeffrey Bell, B.A., 1878), p. 431.

[24] Untersuchungen zur Vorgleichenden Anat. der Wirb., Hft. III., Kopfskelet der Selachier, p. 181, Note, 1872.

[25] Balfour. Development of Elasmobranch Fishes, 1878.

A later contribution to this branch of the subject is contained in a paper entitled "Notes on the Fins of Elasmobranchs, with considerations on the Nature and Homologues of Vertebrate Limbs," by St. George Mivart, published in the Transactions of the Zoölogical Society of London, February, 1879. After noting and discussing the opinions of Oken, Carus, Cuvier, Owen, Gegenbaur, Balfour, Parker, and others, upon this and other questions relating to the history of vertebrate appendages, the author states his conviction "that the nature of the paired and azygos limbs is fundamentally the same." This conviction was formed through finding various degrees of coalescence between the cartilaginous rays supporting the dorsal fins, and various degrees of connection or continuity between such fin-supports and the axial skeleton. *Scyllium canicula*, *Ginglymostoma cirratum*, and still more *Notidanus cinereus*, are examples of this. In the latter, the rays are supported by one continuous basal cartilage. Pristis and Pristiophorus show continuity between the dorsal fin-cartilages and the skeleton, and this may aid in the support of the saw-like rostrum. In Notidanus, Chiloscyllium, and Raia, there is much resemblance between the skeleton of the ventral and dorsal, in Notidanus, between the ventral and anal, while the ventrals of Polyodon are simple parallel rays like the simplest form of the dorsal skeleton. If the ventrals are thus admitted to be of the same nature with the vertical fins, the pectorals must also be of the same nature.

Prof. Mivart endorses the idea of Mr. Thacher with regard to the origin of the limb-girdles, viz.: that they are lateral ingrowths from the skeleton of the paired fins. The objection to this conclusion that has been drawn from the attachment of the pectorals by a shoulder-girdle instead of by direct longitudinal adhesion are met by the considerations that such adhesion would impede the flexure of the body in swimming, that the pectorals are too low to abut directly on the vertebral column, and that such connection is prevented by the intermediation of the body-cavity. The entire theory is thus summarized by Mivart:

1. Two continuous lateral longitudinal folds were developed similar to a dorsal and a ventral fold.

2. Separate, narrow, solid supports, with their long axes di-

rected outwards, were developed to a varying extent along the lines of these folds.

3. The longitudinal folds were interrupted variously, leaving two prominences on each of the lateral folds.

4. The anterior prominences (or limbs) increased more than the posterior.

5. The bases of the cartilaginous supports coalesced according to the needs of the various isolated parts or fins.

6. Occasionally the dorsal radials coalesced, and sought centripetal adhesion to the axis.

7. More constantly the hinder laterals coalesced, and finally prolonged themselves inwards by mesiad growths till such a pelvic structure as is found in Squatina was developed.

8. The pectoral rays also coalesced proximally, and, in search of a support, shot dorsad and ventrad to avoid the visceral cavity. They thus attained the axis above and came together below.

9. The lateral fins, as they were used for support, became elongated and segmented, till probably the propterygium, but possibly the mesopterygium, became the axis of the digit-bearing limb.

10. Pre-existing cartilages were enlarged, or new ones were developed, at the distal ends of the paired limbs, till the cheiropterygium (leg) was developed.

11. The pelvic limb acquired a solid connection with the spine from the need of a firm support on land.

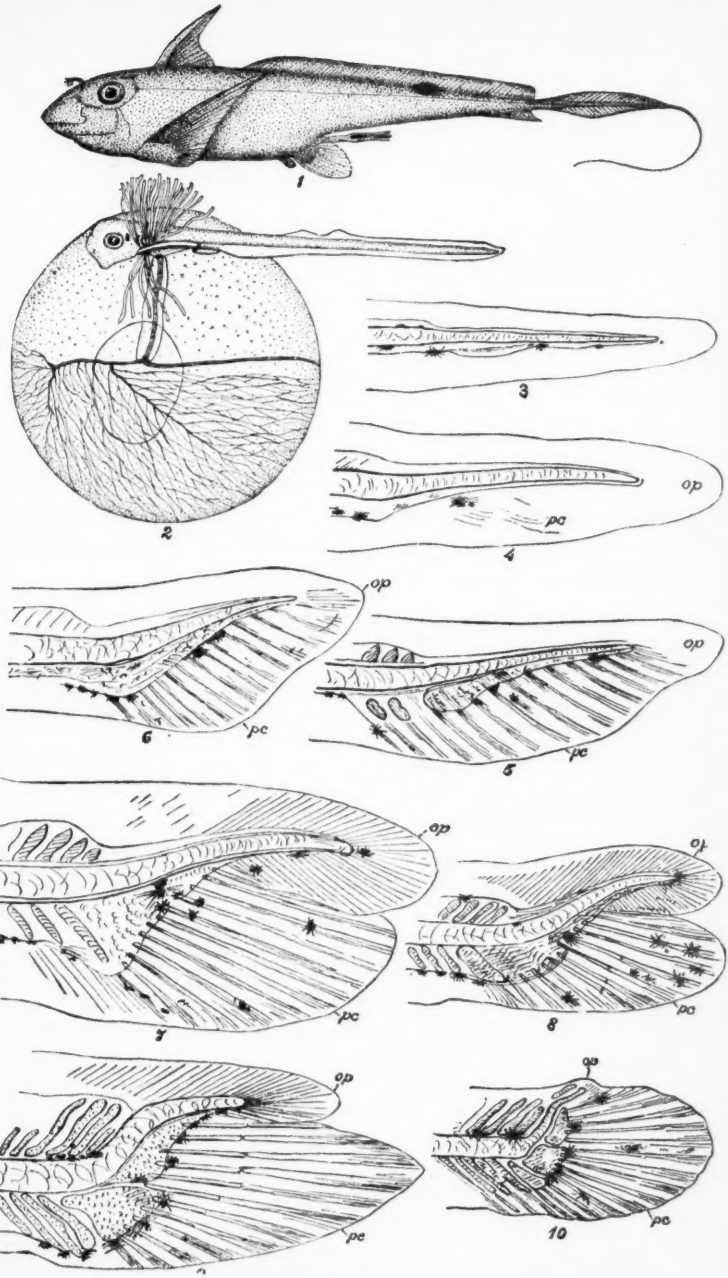
12. The pelvic limb became elongated.

These changes all came about from external causes acting on the plastic animal organism, and the limitation of the paired limbs to four was determined solely by locomotive convenience.

Prof. Mivart gives Mr. Thacher the credit of the first promulgation of the ideas he has adopted, but does not follow the latter in his conclusion that median fin-rays are never derived from neural spines, nor neural spines from fin-rays, as he considers this point to be unsettled, and only capable of proof by the study of their development.

The discovery of the structure of the pectoral and ventral fins in the Ichthyotomi by Sauvage and Döderlein, has substantiated

PLATE XV.



DEVELOPMENT OF THE CAUDAL FIN.

the view of Huxley that the fins of Ceratodus represent the archipterygium or primitive paired fin, as distinguished from a primitive lateral continuous fin, which the theory of Balfour leads us to anticipate may be yet discovered, and which is partly realized in the extinct genus Climatius. And whatever homology may be traced between the paired and median fins, it is evident that the axis of the former has undergone changes which the latter have not experienced. This consists in the sliding proximad of some of the lateral branches of the axis, so that there came to be two, three, or more axial pieces attached to the point of support or scapula. The primitive type is termed by Huxley unibasal, and the later type pluribasal. In the Elasmobranchii the paired fins are unibasal in the Ichthyotomi, and pluribasal in the Selachii. In the Holocephali all are pluribasal. In the Dipnoi the known forms are unibasal. In the Crossopterygia the majority are unibasal, but the order of Cladistia (Polypteridæ) are pluribasal, having two or three (as they are counted) axial bones articulating with the scapula. In other Teleostomata the paired fins are pluribasal, and have mostly lost the axial elements, the basilars only remaining (Fig. 4).

In any case the connection of the paired fins has not been traced to the vertebral axis, as is the case with the median fins, the scapular and pelvic arches being their support in the earliest stages and oldest types known. This has been completely established by the recent researches of Wiedersheim,[26] as far as embryology alone can do it.

As the case at present stands, whatever of proof morphology or embryology furnishes, is in favor of the similar origin and homology of the vertical and paired appendages, but that their relations with the skeletal axis are not identical.

3. ON THE NATURE OF THE SUPPORTS OF THE MEDIAN FINS.

In my memoir on the Fishes of the Lesser Antilles of 1870,[27] as already remarked, I have called attention to the systematic significance of the connection of the fin radii with the vertebral

[26] *Anatomischer Anzeiger*, 1889, No. 4.

[27] Transactions of the American Philosophical Society, p. 450.

column through the intermediation of the supporting elements in certain cases. In a review of Zittel's Paleontology of Fishes, published in 1887,[28] I applied the facts of this part of the struc-

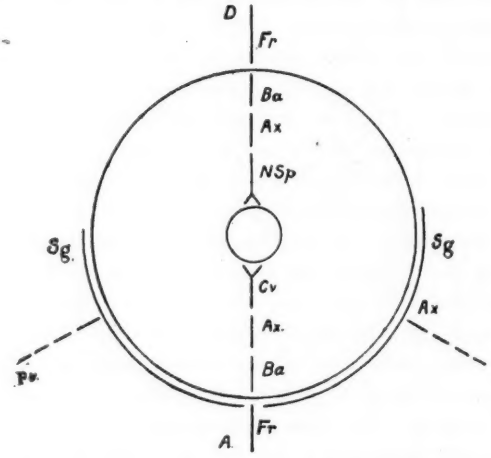


FIG. 6—Diagram representing the elementary constitution of the fins; *D*, dorsal fin; *A*, anal fin; *Pv*, pectoral and ventral fins; *NSp*, neural spine; *Ax*, axonost; *Ba*, baseost; *Fr*, fin-ray; *Cv*, chevron bone; *Sg*, shoulder girdle.

ture to the question of taxonomy and phylogeny more fully, establishing the subclass Rhipidopterygia, and several orders, on the varying characters of the median fin supports. Some additions were made to this system in a "Synopsis of the Families of the Vertebrata," published in 1890.[29] The basis of this analysis is the hypothesis above cited, that the fins represent longitudinal folds of the integument, within which have been developed rods which form a framework connecting the free edges of the folds with the vertebral column. These rods may have been primitively undivided neural spines, but in the oldest forms known to us two segments exist distad to the neural spine. These I have termed the axial and basal elements, or the axonost and the baseost; the latter supporting the fin-rays when they exist. Fin-

[28] AMERICAN NATURALIST, 1887, p. 1016.
[29] AMERICAN NATURALIST, 1889, October, published March, 1890.

rays, however, have developed as a result of specialization of less important and more delicate hair-like bodies, described by previous authors, which traverse the fin from base to border within, and which Prof. Ryder has called actinotrichia, and which he says originate in the mesoderm.

I have determined that continuity of neural spine, axonost and baseost is characteristic of all primitive fishes; while these are again to be distinguished into types which preserve the primitive actinotrichia, and those in which fin-rays are developed. In the latter case the fin-rays are always continuous with the baseosts or axonosts. (Fig. 7.) It has been long known that in modern fishes the axonosts have severed their connections with the neural spines, and do not correspond with them in number or position. The axonosts are then termed interneural and interhæmal bones. It is also a character of modern fishes (most Teleostomata) that the basilar bones are rudimental or wanting. The gradations between the primitive and modern types of fins represent the evolution of the class of fishes, and I have endeavored to express this view in the system which I have proposed, as above cited. (Am. Nat., October, 1889.)

The various stages or types of dorsal and anal fin structure may be defined as follows; and it seems necessary to give them names, to avoid the circumlocution requisite to express the characters in any other way. The diagrams appended explain the types referred to. They are applicable to the dorsal fin, and, inverted, to the anal fin. Each separate series in its totality is called by Ryder the actinophore. Its kinds are the following:

I. Actinotrichia present.

Neural spine, axonost and baseost continuous; *Entotetramerous.*

II. Fin-rays present.

All the elements present and continuous; *Ectetramerous.*

All the elements present, the axonosts not anticulated with the neural spines; *Ectrimerous.*

Like the last, but the baseosts rudimental or wanting; *Ecdimerous.*

Axonosts not connected with the neural spines, reduced to one or two for each fin; *Rhipidopterygian.*

As I have already pointed out, there are two types of the Rhipidopterygian fin, the Rhipidistious where baseosts are present (teste, Traquair), and the Actinistious (Fig. 8) where they are wanting. These divisions, corresponding to orders, do not require renaming.

No fishes are known with the actinophore dislocated from the neural spines, and retaining actinotrichia. Should such be discovered, they will appropriately receive names similar to those given to the series with fin-rays, with the prefix ento, as entotrimerous, entodimerous, etc. For obvious reasons the discovery of an entotrimerous fish is more probable than that of an entodimerous one.

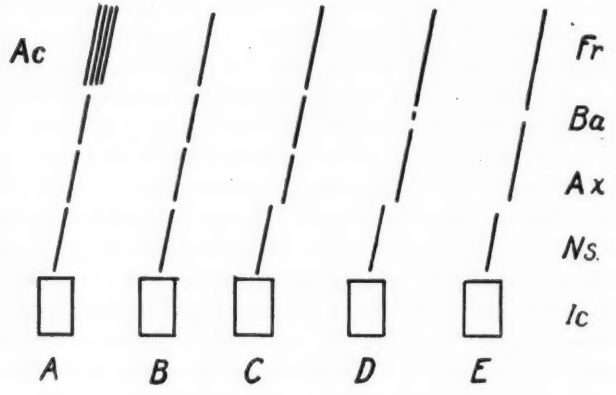
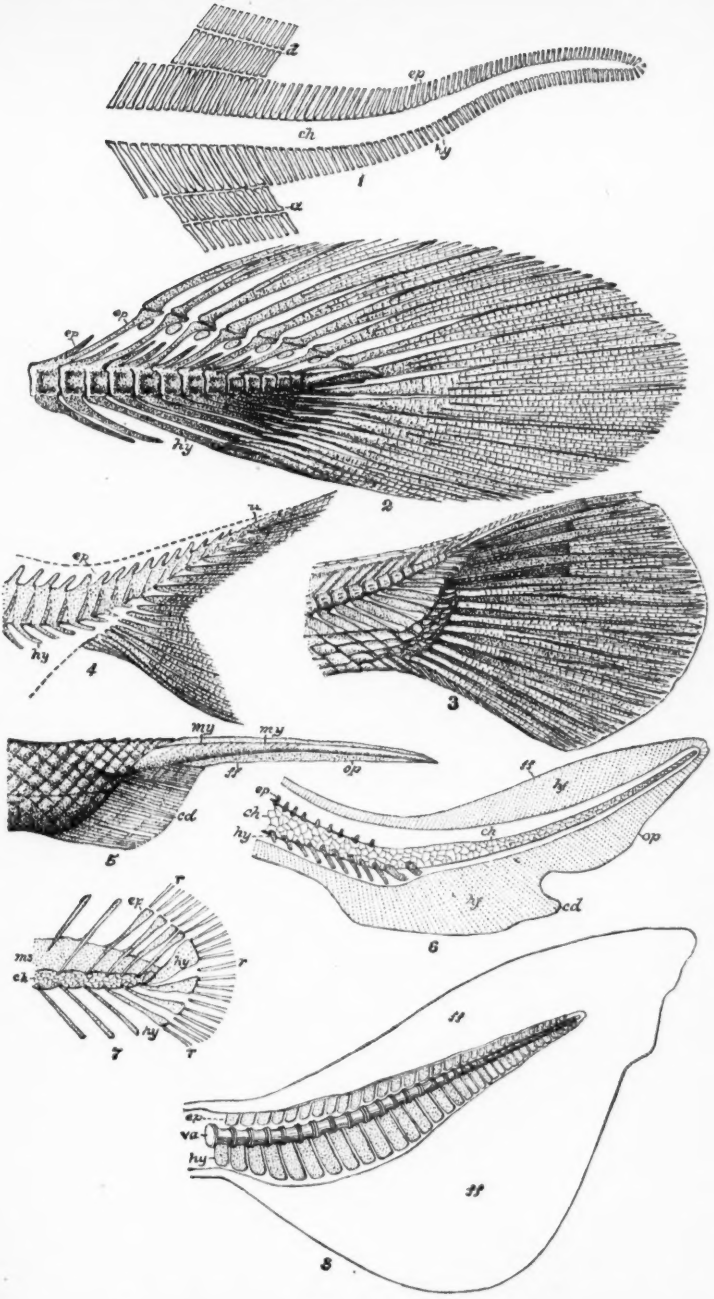


FIG. 7.—Diagrams of actinophores; *A*, entotetramerous; *B*, ectetramerous; *C*, ectrimerous; *D* and *E*, ecdimerous; *Ac*, actinotrichlia; *Fr*, fin-rays; *Ba*, basiost; *Ax*, axonost; *Ic*, intercentrum.

As regards the origin of the actinophores, Gegenbaur suggests that they were derived by segmentation from neural spines, while Thacher believes that they originated independently of the latter. Thacher bases his views on the structure found to exist in Selachii, which he supposes to represent the most primitive condition. The Selachii must, however, be regarded as, in many respects, degenerate, and Xenacanthus is probably more primitive. It is proba-

PLATE XVI.



Diphycercal and Heterocercal Caudal Fins.

ble however that Thacher's opinion is correct, but not for the reasons which he gives. I have oberved in a memoir On the Mechanical Origin of the Hind Parts of the Mammalia,[30] that "the mechanical cause of the origin of neurals pines may be traced to the strains upon the vertebral axis caused by a primary dorsal fold, or fin."[30] On this view the actinophores and the neural spines were simultaneously developed in lines of strain which naturally extend to the point of resistance nearest to the moving fin-fold, viz.: the apex of the neurapophysis. The development of the segments neural spine, axonost, and baseost was then simultaneous, and the one segment was not derived from the other. Thus the views of both Gegenbaur and Thacher are partially justified.

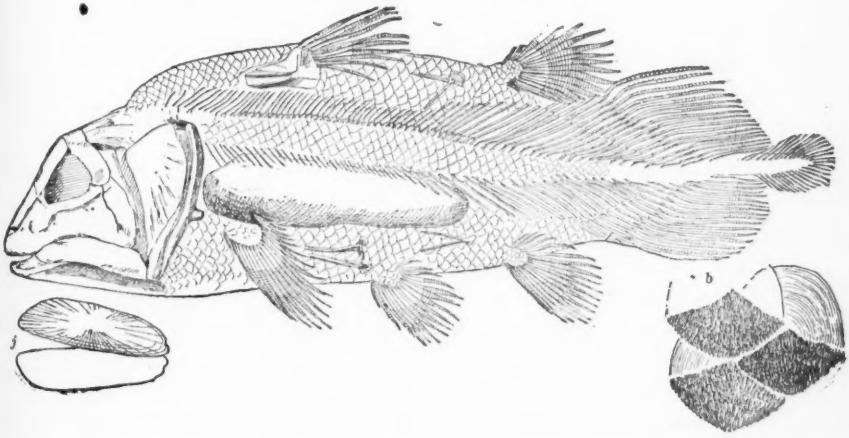


FIG. 8.—*Undina penicillata*, one-third natural size, showing rhipidopterygian and actinistious types of fins; *j*, jugular plates; *b*, scales of *Undina acutidens*; from Zittel.

The development of the appendicular skeleton is now shown to have proceeded from without inwards, and thus the homologies of the parts of the actinophores of all the fins must be interpreted from the same point of view, *i. e.*, from without inwards.

[30] *American Journal of Morphology*, 1889, p. 210.

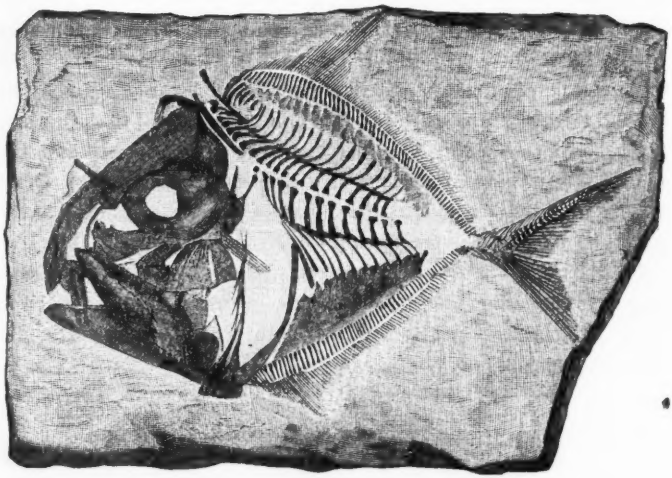


FIG. 9.—*Dorypterus althausii*, ½, representing the order Docopteri, an actinopterygian fish from the Trias, with well developed baseosts of the median fins, and axonosts apparently continuous with the neural spines; from Zittel.

4. ON THE CAUDAL FIN AND ITS SUPPORTS.

Professor Louis Agassiz first called attention to the diversities in the structures of the caudal fins of fishes, and their relation to the general history of the class. He showed that the tails of modern fishes are constructed on two different patterns, which he called the homocercal and the heterocercal. In the former, the radial portion of the fin is in two unequal lobes, the superior being the more produced distally, and the inferior occupying a position on its inferior aspect, and having a much less degree of posterior prolongation. In the latter, the inferior lobe is of equal length and posterior prolongation with the superior. He showed that the homocercal type is characteristic of all Paleozoic and most of the Mesozoic fishes known to him, while the heterocercal type predominates in the Cenozoic and existing fishes. He also showed by a study of the embryology of the trout and other forms, that in their earlier stages the heterocercal fishes are homocercal. These results he regarded as important, and, in fact, they

constituted the first intelligent application of the structural characters of fishes' fins to their systematic arrangement, which was made.

Subsequently the paleontologist McCoy,[31] observed that in some extinct fishes the vertebral column did not enter the superior part of the caudal fin, but continued directly to its middle base, and terminated without modification, the rods supporting the fin radiating equally and symmetrically above and below to the extremity. This type of fin he called diphycercal.

Later, Huxley[32] studied the development of the caudal fin in the salmon, and showed that although the caudal fin proper is heterocercal, some of the terminal vertebræ enter the base of the superior lobe, thus having a partially heterocercal structure.

Cope, in 1871,[33] reviewed the structure of the caudal fins of recent and extinct fishes. He stated that the diphycercal type (which he termed isocercal in ignorance of McCoy's paper) is the primitive condition of this region, preceding the homocercal in embryonic history. He showed that it persists in various modern fishes, as in the Lepidosiren and Polypterus, and among Telestomata, in the eel-like types, in the Gymnarchidæ, and in the Anacanthini, and in the last-named supporting a heterocercal caudal fin. He also showed that in various living isospondylous fishes besides the salmon, a partially homocercal condition persists, notably in the Notopteridæ.

A valuable contribution to this subject is that of E. T. Newton,[34] who has worked out some of the developmental stages of the sprat, and brings together the works of several earlier writers upon the subject. No notice is taken in this pamphlet of the writings of Cope, Wilder, and other American naturalists who have at various times observed or reasoned out the steps by which the primitive vertical fold becomes a highly differentiated caudal fin.

[31] *Annals Magaz. Nat. Hist.*, 1848, p. 304.

[32] *Quarterly Journal Microscop. Science*, 1859, p. 33.

[33] Transactions of the American Philosophical Society, XIV., 1870, pp. 452, 453.

[34] On Fishes' Tails, by E. T. Newton, F.G.S. Ext. from the *Journal of the Queckett Microscopical Club*, July, 1882.

Ryder has given a very full account of the embryology of fishes' fins, which has especial reference to the caudal region.[35] He distinguishes six stages in the development of the caudal fin as follows:

1. Archicercy; no caudal fin-folds. 2. Lophocercy; caudal fin folds, with or without actinotrichia. 3. Diphycercy; 4, Heterocercy; and 5, Homocercy, as above defined. 6. Gephyrocercy, in which the terminal vertebræ are aborted, so that a hiatus is created between the neural and hæmal elements, or actinophores, at the extremity of the axis. This structure occurs in Echiodon (Pl. XVIII., Fig. 3,) Mola, etc. In this case the epaxial and hypaxial tegumentary folds are continuous round the extremity of the vertebral axis, and develop fin-rays which appear later than those of the dorsal and anal fins. This is supposed to be a condition of degeneracy.

The subject is treated histologically and embryologically by Ryder, who reviews the work of various authors who have viewed it from the same standpoint, especially Vogt, Kölliker, Dohrn, and Lotz.

The latest contribution to the subject is one by Baur, who shows that the rods (axonosts) which connect the rays of the anal fin with the inferior side of the caudal vertebræ, in Lepidosteus, are chevron bones.[36] This agrees with the determination by Cope[37] that the vertebral bodies of fishes are intercentra, and not centra.

From the researches already cited it is now well understood that in the caudal fin as in other fins, the primitive actinotrichia have become specialized into fin-rays, and that these approximate more nearly to the number of their osseous supports than do the actinotrichia. They are rarely so reduced in number, however, as to correspond exactly to the hypural bones.

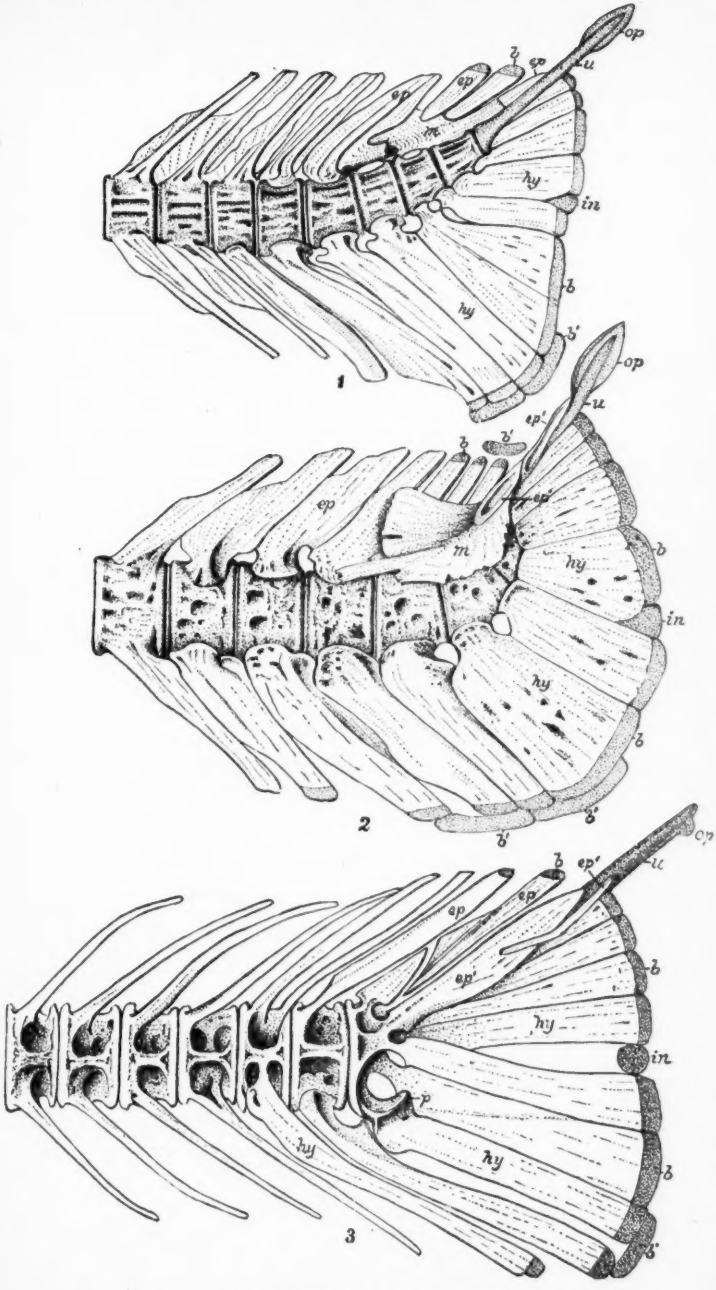
The actinophores of the caudal fin may or may not have been primitively divided like those of the other median fins into

[35] Annual Report of the U. S. Commissioner of Fishes and Fisheries, 1886, pp. 981-1086.

[36] *Amer. Journal of Morphology*, 1889, p. 463. Dr. Baur inadvertently calls the axonosts "actinosts."

[37] Transac. Amer. Philosoph. Society, 1886, p. 243.

PLATE XVII.



HOMOCERCAL CAUDAL FINS.

(chevron) axonost and baseost. Such appears to have been the case with the Dipnoi, but whether it is strictly the case in the primitive Xenacanthus remains to be ascertained. The axonost and baseost are lost from the modern types of diphycercal tails, as Anguilla (Ryder, Pl. IV., Fig. 4) and Gadus.

The change from diphycercy to heterocercy is seen in the upward curvature of the extremity of the vertebral column, and the development of a portion of the inferior fin (anal) into a posteriorly projecting angle. This is the state of affairs in the Elasmobranchii, Chondrostei, and various extinct Teleostomata.

The change from heterocercy to homocercy is seen in the increased recurvature of the column, and the successive abortion of its extremity. This is accompanied by the increase in antero-posterior diameter of the hypural bones, especially distally, since they develop to occupy the space gained by the recurvature. The neural spines corresponding to them become correspondingly reduced. Such modified elements have been called (provisionally) hypural bones. All stages of development of these bones may be formed in the Teleostomata. Thus in the lower forms (most Malacopterygia) they remain distinct from each other. In many of the Acanthopterygia—e. g., Cottus, (Pl. XVIII., Fig. 1,) and Pharyngognathi, they are fused together, forming a continuous fan-shaped body, which supports the fin-rays directly.

The different types of hypural bones are well illustrated in the accompanying plates from Ryder.

Explanation of the Plates.

For the Plates XV. to XVIII., which are taken from those illustrating Professor J. A. Ryder's memoir on "The Origin of Heterocercy," I am indebted to the Hon. Marshall MacDonald, U. S. Commissioner of Fish and Fisheries.

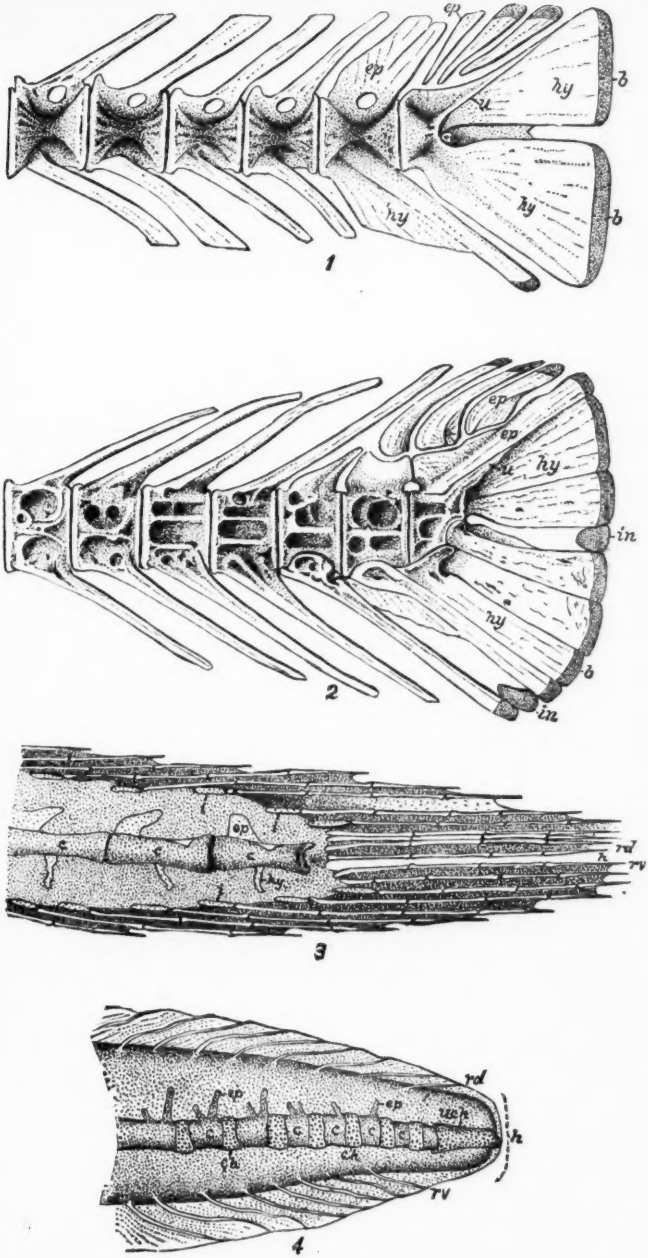
Plate XIV.—Restoration of *Xenacanthus decheni*, an Ichthyotomous Elasmobranch from the Coal Measures of Alsace, much reduced. From Brongniart and Sauvage.

Plate XV.—Fig. 1, *Chimæra monstrosa* L. ♂. Fig. reduced from Agassiz's Poissons Fossiles, showing opisthural filament. Fig. 2, Side view

of embryo ray in the lophocercal stage, natural size, from a specimen taken near Wood's Holl, Mass. Fig. 3, Lophocercal tail of young flounder 6 mm. long. Fig. 4, Lophocercal tail of young flounder a little older than the preceding, beginning to show a slight upbending of the notochord, and the first trace of the permanent caudal lobe (*pc*) and opisthural lobe (*op*). Fig. 5, Caudal lobe of a somewhat older flounder, showing indentation and definition of permanent fin-rays. Fig. 6, Specimen with tip of notochord still more reflexed than in the preceding; permanent caudal and opisthural lobes somewhat more distinct. Fig. 7, Permanent (*pc*) and opisthural lobes (*op*) now form a sharp angle where they join; distinction between permanent and embryonic rays well marked. Fig. 8, Permanent caudal as long as opisthural lobe (*op*). Fig. 9, Cartilaginous supports of fin-rays are now strongly developed; the end of the chorda has begun to degenerate and approximate the position which it will occupy permanently as the urostyle. Fig. 10, The caudal has become more rounded, the opisthure (*op*) is almost wholly absorbed, and the notochord has suffered atrophy somewhat, and now presents a still closer approximation to the form of the urostyle of the adult. Figs. 3–10 inclusive after A. Agassiz.

PLATE XVI.—Fig. 1, Caudal skeleton of Coccosteus after Pander; *ep* and *hy*, epural and hypural elements, all of which do not bear rays, but as in Pterichthys, extended out only so far as the scaly covering of the tail; *d*, dorsal; *a*, anal fins. Fig. 2, *Polypterus bichir*, caudal skeleton, from Agassiz's Poissons Fossiles, modified from Kölliker; *ep*, styliform ray-bearing and nodular non-ray-bearing interspinous epural elements; *ep*, neural spines; *hy*, hypural ray-bearing elements. Fig. 3, Lepidosteus, caudal skeleton from Kölliker, adult; showing urochord more prolonged and attenuated than in the preceding. Fig. 4, Platysomus restored, after Agassiz's Poissons Fossiles; *ep* and *hy* epural and hypural pieces; *u*, urochordal end of skeletal axis, which was mainly notochordal. Fig. 5. Lepidosteus, tail of young specimen 11 cm. long, from Balfour and Parker; *cd*, permanent caudal; *ff*, eradiate fin fold of opisthure; *op*, opisthure; *my my*, its myotomes. Fig. 6, Lepidosteus, young, 21 mm. long, side view; dissected and magnified so as to show its structure at this stage; *ep* and *hy*, epural and hypural cartilaginous rudiments of the neural and hæmal arches; *ch*, chorda; *cb*, its opisthural portion, which afterwards becomes partially aborted and included in the upper part of the tail; *cd*, tip of fold, which becomes the permanent caudal; *op*, opisthural lobe of the larval tail; *ff*, lophocercal finfold, which contains horn-fibres throughout its extent, *hf*. After Balfour and Parker. Fig. 7, Magnified view of the caudal skeleton of a young Cyprinodont, Gambusia, ⅓ of an inch long, and which was removed from the ovarian follicle in which it developed; *ch*, chorda dorsalis; *ep* and *hy*, epural and hypural cartilages; *ms*, medulla spinalis; *r r r*, rays. Fig. 8, *Centrina salviani*, caudal skeleton of adult; *ep* and *hy*, as before; *va*, ver-

PLATE XVIII.



HOMOCERCAL AND GEPHYROCERCAL FINS.

tebral axis; *ff ff*, its dorsal and ventral membranous lobes, which include numerous horny and partly osseous supporting fibres. From Günther.

PLATE XVII.—Fig. 1, *Salmo fario*, adult, caudal skeleton; *b* and *bi*, basilar cartilages; *ep*, epural, and *hy*, hypural elements; *m*, lateral membrane bone, which has had an epural cartilaginous element as its nucleus; *in*, intercalary cartilage; *u*, urostyle; *op*, opisthure. After Lotz. Fig 2, *Salmo salar*, adult, caudal skeleton; lettering as in Fig. 1. From Lotz. Fig. 3, *Barbus fluviatilis*, adult, caudal skeleton; lettering as before. From Lotz.

PLATE XVIII.—Fig. 1, *Cottus gobio*, adult, caudal skeleton; lettering as in Plate XVI. From Lotz. Fig. 2, *Perca fluviatilis*, adult, caudal skeleton; lettering as before. From Lotz. Fig. 3, *Echiodon dentatus*, adult, gephyrocercal caudal extremity; *c*, centra; *ep* and *hy*, hypural processes; *b*, basilar cartilages: *i*, interspinous cartilages; *h*, hiatus between dorsal rays (*rd*) and postanal rays (*rv*); x 17. From Emery. Fig. 4, *Fierasfer acus*, gephyrocercal caudal extremity; *ep*, epural processes; *c c c*, centra not in contact; *ch ch ch*, membranous or cartilaginous central intervals; *uch*, exserted end of chorda, or urochord; *h*, hiatus between last dorsal rays (*rd*) and last postanal rays (*rv*); x 55. From Emery.

A ZOÖLOGICAL RECONNOISSANCE IN GRAND MANAN.

BY J. WALTER FEWKES.

ON the side towards Eastport, Grand Manan presents a series of lofty cliffs rising abruptly out of the sea, so precipitously that it would be almost impossible to climb from the shore to their summits. Only in a few places is this rampart broken through, leaving sheltered coves where boats can find anchorage. Ordinarily the lofty cliffs rise abruptly from the sea, and the few stretches of beach crowded in between the foot of the cliff and the water are exceptional, and limited in extent. Deep into this lofty buttress of rock there extends at one point on this side of the island a deep fiord, known as Dark Harbor, so-called because in former times its heights were covered with sombre trees. The

sides of these hills have been denuded by forest fires of their ancient woody covering. This fiord, however, is a harbor only in name, and while it may have been formerly a bay, there now stretches across its entrance a low beach formed of cobble-stones, effectually shutting out its deeper waters from the sea outside. It still has communication with the Bay of Fundy by means of a small artificial channel through which the waters rise and fall twice every day, the still lagoon feeling the influence of the giant tides, for which this region is remarkable. Around the base of the lofty cliffs sweep the strong and swift currents which the great tides create. Sometimes this moving water is irresistible, carrying everything along with it as it sets back and forth under the brow of the high land which forms the dike or backbone of the island.

Under these lofty cliffs the fisherman spreads his net or casts his lines, and the Passamaquoddy Indian still as of old hunts the porpoise from his frail canoe, and on the scanty beaches at the base of the cliffs he tries out the oil. His picturesque but not over-clean huts, perched on the side hills, and a few houses at Dark Harbor, are the only habitations of man on this side of the island, save the isolated light-house and the home of the light-keeper.

But there is another shore of Grand Manan which is very different from that we have mentioned. The coast on this side is less rugged and more inviting as a landing-place, and on this shore there are many harbors protected by out-lying islands, in which fishing craft ride at anchor. Here the land slopes more gradually to the water's edge, and the coast is indented by frequent bays and coves.[1] Through the channels which separate the islands from the shore line currents similar to those on the other side of the island make their way with great power, and the ebb-tides cause the water to retreat so far that the coves are often left bare by the retreating water. But here the coast is more hospitable, and more like the adjacent shores of New England.

[1] Among many geological evidences of erosion on this shore, not the least interesting are the examples of "pot-holes," or "giant's kettles," found between Seal Cove and Grand Harbor, not far from the main road. The well-marked prismatic and columnar structure of the dike which forms the lofty cliff is well shown at Southern Head, near the light-house.

Upon this shore most of the homes of the inhabitants of Grand Manan are situated, for here are clustered the small villages of fishermen's houses, scattered in hamlets here and there at intervals from one end to the other of the island. Along this shore wharves are frequent, and several small villages lie nestled near the water's edge, on well protected bays.

At a point about midway from one end of the island to the other there is a group of houses called Woodward's Cove. The main road from North Head, where the steamer lands, to the opposite extremity of the island, skirts the shore, leaving only the landing places, upon which are situated a few houses for smoking herring, between it and the water. The place is a picturesque one, and interesting in many ways, but perhaps more especially to me, since around it cluster pleasant recollections of a summer's vacation passed on Grand Manan, in the study of the rich marine life of the island.

Just opposite Woodward's Cove lies an island called Nantucket. Why so named, or whether the story of its southern namesake is here repeated, I have never been able to discover. It is but one of the numerous islands which rise here and there from the shallow platform between the main island and the deep water of the Bay of Fundy.

My first visit to Nantucket was during a thick fog. Alighting with baggage from the carriage which carries passengers and mail from one end of the island to the other, I found myself in Woodward's Cove in the midst of a thick fog. So dense was the fog, in fact, that I was obliged to trust the statement of the boatman that Nantucket existed at all. No land was visible as we pushed off from the shore and headed our boat in a direction in which the island was known to lie, and we had to trust our boatman, and patiently wait until we reached the other side of the channel before we were at all sure of its existence. The certainty with which the fishermen of Grand Manan can find their way in the thickest fog is marvelous. Thoroughly trained in navigation in these waters, every incident, every sound, guides their course when sight fails; the direction of the wind

the set of the tide, the ripple of the water on the rocks or beach, the gun from the distant Gannet Rock, all contribute to a keen sense of direction by which these men find their way to their fishing grounds and back in a thick fog, when one not skilled in this knowledge would lose his way, or, bewildered, would lay his course to the distant shore of Nova Scotia, or the broad open entrance to the Bay of Fundy.

Nantucket is known far and wide among naturalists as the home of Mr. Simeon Cheney. This gentleman was well called by Professor Baird a "natural naturalist." He is an acute observer of nature, a good collector, a tireless worker, and one whose interest in natural history age but increases, and whose energy in his old age many younger naturalists have good cause to remember. It was my purpose to spend a few weeks with him on Nantucket studying the sea animals of this interesting locality.[2] My visit was not unrewarded, and I have good reason to congratulate myself that the choice of this island was made. I was accompanied and aided in my work by an enthusiastic student of natural history, Mr. J. G. Owens, of Bridgeton, New Jersey.

On coasts where the tides are high, and other conditions favorable, the collecting of the marine life which is characteristic of the shore, is, as a rule, very profitable. Similar conditions to those which are found at Nantucket exist along the coast of the English Channel, and in Brittany on the coast of France. The same tidal characteristics are found about Eastport, and at other places in Maine. Grand Manan offers many advantages for the study of marine animals, while the outlying islands, reefs, and ledges left bare by the retreating tide present unparalleled resources for collecting the varied life of the north-eastern coast. As time goes by and as naturalists turn their steps more and more frequently to the shores to investigate the marine life, these islands will be more and more visited, and it is to be hoped that they will acquire an ever-increasing reputation for the many advantages which they possess for the study of these animals in

[2] I can recommend Nantucket as better than any place on the coast of New England for "show collecting."

their native haunts.[3] If it may be permitted me to speak with enthusiasm I may say that marine zoölogists have hardly begun to appreciate the wealth of life round about this island, which lies comparatively speaking at our very doors, and simply awaits an investigation.

The opportunities for work at Grand Manan with the dip-net in the study of free-swimming animals are also very great. The student of these forms of life is particularly recommended to visit the so-called "Ripplings" or tide eddies, several miles from the shore, near the line where the platform of the islands sinks to the deeper sounding of the Bay of Fundy. These eddies are favorite feeding places of many marine animals, from the whale to the minute Medusæ and Crustacea, and at a proper time of the tide afford most profitable collecting places. The distance from the shore and the difficulty of access is the only drawback, but if possible they should be visited by every naturalist who is interested in the study of marine life in its natural habitat. A world for investigation here awaits the attention of the naturalist.

Of those who have visited Grand Manan, and left valuable publications adding greatly to our knowledge of the marine life of the place, prominent among all should be mentioned the name of Dr. William Stimpson. Many others have worked here, but as the group of animals which it was my purpose to study had been more particularly considered by him I mention his name with especial indebtedness. I went to Grand Manan to study the lower Invertebrata, and my studies of this group found in this locality were greatly aided by his previous studies. It does not detract from my appreciation of the value of the works of others that I have singled out his work as of greater use to me, and his paper is recommended as one of many valuable companions for those who would visit this island for a purpose similar to my own.

My object in spending a vacation on Nantucket was to study the Cœlenterata and Echinodermata, more especially the changes

[3] Grand Manan had last summer a tri-weekly communication with Eastport by the mail steamer *Flushing*. Eastport can be reached from Boston by the steamers of the International Line, also called the St. John's steamers. The trip to Eastport by rail from Boston to Calais, and then by steamer down the St. Croix river, gives the visitor much scenic beauty.

in form which certain members of these groups pass through in their development. There are certainly many remarkable genera of these animals found nearer home, of the young of which little is known, but I aspired to trace the changes in the external form of the body of the young of those of which we know next to nothing, since many of these animals are more numerous at Grand Manan than elsewhere on our coast. The study of the Echinoderms, and the desire to trace the development of certain genera, are subjects which have interested me for several years, and these studies can be pursued with great advantage on the shore of Grand Manan. No locality on the coast is more prolific in Echinoderm life than this, and here occur animals the problems connected with which rank among the more interesting of those presented to the consideration of the morphologist.

Looking, for instance, from the embryological standpoint, we have of starfish the genus Hippasterias, of the young of which nothing is known. Pteraster, also found in these waters, carries its young in pouches on the back or aboral side of the body. It presents interesting problems of the nature and significance of direct development. Among these animals, with the exception of a pair of figures of a single stage of the young, nothing is known of the embryology of this marvelous genus. Then there is Ctenodiscus, whose young have a strange projection on the middle of the dorsal region of the body, reminding one of the stem of a Crinoid. Of the young of Solaster and Crossaster we know nothing. Moreover, the affinities of the latter with Brisinga, which has likenesses itself to the Ophiurans, are such that a study of its young promises interesting morphological results.

Although many points which I hoped to investigate I was unable to make out, my visit was not wholly without valuable results.

My search for the Comatula described by Stimpson from Grand Manan was without success. Familiar with the places which this animal loves on other coasts, I looked in similar localities along the shore, among the laminarians on the Fucus, everywhere, but always with disappointment. I gave it up at last, and concluded that the specimen which he found was a straggler from

some congenial home. Not that I hoped to discover anything new in relation to the development of the young of this animal, for the changes which it passes through are well known, but it would have been a pleasure to be the second person to detect here this rare animal, if its home is really in the waters of Grand Manan. That pleasure would have been enhanced by the fact that since the time when this little creature was found by Stimpson in these waters genera and species of this animal have been described, and it would have been a satisfaction to know whether or not his specimen belongs to some species twice made known, for until this animal is once more found and compared either with types or with descriptions we must remain in doubt what it is or to what species it is allied.

We also searched in vain for the "basket-fish," *Gorgonocephalus agassizii*. Fresh from dredging excursions in the channel between Eastport and Campobello, where, as under the brow of the "Friar," many of these Echinoderms are brought up in the dredge, it was a surprise that this interesting creature was not found in our work. Distant trips to remote dredging grounds failed to reward us. A trip to the side of the island under the lofty cliffs near the Indian encampment, where it is said to exist in numbers, was without result. But always, like a phantasmagoria, the stories of the fishermen led us on. There is no doubt that the "basket-fish" is to be found there, but where it occurs we were not fortunate enough to discover. An account of the metamorphosis which it passes through between the egg and adult would be a substantial contribution to our knowledge of Echinoderm development.

But the rewards which came to us in collecting Ophiurans more than made up for our want of success in regard to Comatula and Gorgonocephalus. Nowhere have I seen a richer harvest of the genera Ophiopholis, Amphiura, Ophioglypha, and Ophiacantha. A favorite collecting place for the first of these is on the shore opposite Mr. Cheney's house. On the point left bare by the retreating tide hardly a single stone could be raised without disturbing an Ophiuran hidden under its cover. These animals have a variety of colors, with markings of many patterns, but all belong to

the same species, *Ophiopholis aculeata.* In the channel off the Weirs between High Duck Island and Nantucket we dredged bushels of these animals so crowded together that the dredge bay was simply gorged with them. A motley crowd they were, too, as we emptied the dredge in the bottom of the boat. My friend and fellow-student, to whom this was the first introduction to these animals, was beside himself with joy, but subsequent repetition of these hauls renders even the most enthusiastic less anxious to secure specimens, and we came to wish that something else from the sea bottom might have a chance.

Amphiura squamata was not found as abundant as *O. aculeata.* We picked them up among the small stones, sometimes in the coralline zone, but never as abundant as the Ophiopholis. The characteristic Ophiocoma and Ophiacantha were dredged more sparingly, but they may be said to occur in numbers off High Duck Island and Nantucket. We never collected these genera on the shore between tides in places where Ophiopholis and Amphiura love so much to dwell.

All of the many genera of starfishes which live in the waters of Grand Manan were found in our several dredging excursions.

Among the most interesting of the Asteroidea are the beautiful species of Hippasterias, two of which were dredged off Long Island in comparatively shallow water. Crossaster was taken in the channel between Long Island and High Duck, while Solaster was found at various points near low water mark. The latter was often taken with the boat hook, and in collecting could sometimes be readily seen from the boat when the water was quiet.

Innumerable specimens of three species of Asterias, some of which are of giant size, occur in the passage ways between the islands, and were readily found and preserved. [4] Crebrella, which is very common at Grand Manan, is found in all conditions of

[4] Our method of successful preservation of these Echinoderms was to place them first in fresh water until the rays were extended and the body inflated, then, plunging them into boiling hot water, they were allowed to remain there for from three to five minutes. They were then baked in an oven or over the stove, never, however, allowing them to become over-heated. It was best to cut out the hepatic cœca of the genus Hippasterias by an in cision in the angle of the arm before baking, otherwise the body of the starfish is blackened by the exuding matter from this organ.

growth. A colony composed of fifty or more, each resembling a bright red spot on the rock, was taken by my friend Mr. Owens. The young of Crebrella when the arms begin to push out from a pentagonal disk do not differ from those of Asterias, but as the arms develop it was found that there was no prominent row of dorsals, and that the plates were irregularly scattered over the back.

The number of individuals of the Echinoidea at Grand Manan is very great, but the variety is small. Echinarachnius and Strongylocentrotus are the most common. The former were often found in such abundance as to clog our dredge, and on the points of land at low tide we gathered many on the shore. White specimens of Strongylocentrotus were found which resemble in every respect the green colored. The boring habits of this genera I have already mentioned in a former number of the NATURALIST.

The gaint among the Holothurians, *Pentacta frondosa*, is very common at Grand Manan, where it is known as the "sea pudding." Cuvieria is rare, but its bright red body may often be detected as the animal clings by its suckers to the rocks at the line of low tide. This Holothurian is sometimes called the "sea orange" or "sea lemon." The very young Cuvieria were found clinging to the rocks by two terminal suckers, in which are embedded scales composed of an open calcareous lattice-work. Scales or perforated plates are also found in the tentacles, which are but little branched. In the younger stages the color of Cuvieria reminds one of a young Actinian.

The summer of 1889 at Grand Manan was exceptional in the variety of animals from southern waters which were collected. Among these were *Physalia arethusa*, and the well-known Anatifer which is often so common in Narragansett Bay. A floating half cocoanut, covered with the ordinary "Goose Barnacle," was picked in the bay near Gannet Rock. The long voyage which this fragment had taken in the waters of the Gulf Stream need not surprise one; but the fact that it was found in the cold waters of the Bay of Fundy is an unusual one. All the hydroids mentioned by Stimpson, with the exception of Grammaria, were collected by us. In place of this problematical genus a beautiful

Antennularia, which closely resembles Grammaria, which has never been found in the Bay of Fundy, was taken on several excursions. Halecium, a hydroid not described by Stimpson, but not unknown from Grand Manan, is one of the most common of the hydroids observed, while Eudendrium, Tubularia, Corymorpha, Clava, Campanularia, and various genera of Plumularidæ and Sertularidæ are very abundant. There is no subject which would yield better results in the study of our marine animals than that of the hydroids of the waters about Grand Manan. Very little research on these animals from the Bay of Fundy has yet been carried on.

A genus allied to Myriothela also occurs at Grand Manan. The genus called Acaulis was discovered at Grand Manan, and described by Stimpson, who failed, however, to recognize its affinities with Myriothela. The true relation of the genus Acaulis has been for many years[5] problematical with me, and I have been led to regard it as the broken head of a Tubularian, following the opinion of several well-known naturalists in this identification. A study of the living specimens of Myriothela, and an examination of the unpublished figures of the Eastport representative, made over ten years ago by Professor Hyatt, and loaned to me for study, leads me to place Acaulis in the neighborhood of Myriothela, retaining Stimpson's name for it until a new examination can be made to determine its true systematic position. Stimpson's description is quoted below verbatim, in order that what is at present known of this animal may preface a few conclusions of my own, drawn from an examination of Prof. Hyatt's drawings.

FIG. 2.—Acaulis. (A. Hyatt, del).

Stimpson's account of Acaulis ["Invertebrata of Grand Manan"] is as follows:

[5] My examination of specimens of Myriothela found at Roscoff, France, convinced me that Acaulis is a close ally of this interesting genus. On several visits to Eastport and Grand Manan I have repeatedly looked for both Myriothela and Acaulis, but have never been able to find either.

"ACAULIS, St. n. g.

A. primarius, St. n. s., Fig. 4. The remarkable polyp for which this name is proposed, which is probably the largest hydroid known,[6] was observed at Grand Manan in two successive stages of development. It was first taken early in August, when it was of a sub-cylindrical form, tapering suddenly to a point at each extremity. At the upper extremity was the mouth, very small, a little below which the tentacula commenced, scattered at first, but gradually increasing in number, and somewhat in size. These tentacula were minute, very short, equaling in length about one-sixth the thickness of the body, with large globular tips. They occupied about two thirds of the body; on the remainder below, their places were supplied by the medusa buds, which were crowded, and much larger than the tentacula although as yet but little developed. The inferior extremity of the body terminated in a short, pointed, fleshy spike, free from appendages, from which exuded a tenacious mucus, by which it adhered to the subaqueous surfaces to which it might be applied. Around the base of this spike, and immediately under the buds, were regularly arranged eight long gracefully-curved cirriform processes, each equaling in length about half that of the body. These appeared from their motions to be in this—the first stage of the animal's existence—the locomotive organs.

"At a subsequent time I met with several of these animals which presented a different appearance. The tentacula were larger, especially in the region of the mouth, at the now blunt extremity of the body; and the medusa buds were in an advanced state of development, soon to become free-swimming individuals. The inferior appendages had disappeared, and the body was firmly attached by a broad base, and bore much resemblance to one of the ordinary Corynidæ deprived of its stalk. In strong contractions it assumed a shape approaching an hour-glass. The length of the animal in this latter stage was half an inch, the breadth two-tenths. In the earlier stage the dimensions were one-half these.

[6] The giants added to the Hydroidea of the deep sea by the explorations of late years were unknown when this was written by Stimpson.

"It was dredged in the laminarian, from 5 to 15 feet, attached to various Rhodosperms, as Ptilota, Chondrus and Rhodymenia. Circumstances did not permit me to ascertain the medusoid form of this polyp, although I have my conjecture."

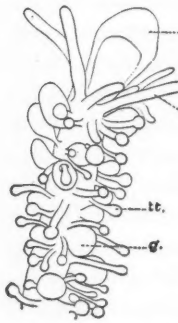


FIG. 3.—View of anterior end of Acaulis, showing temporary tentacles *tt* (A. Hyatt, del.)

Prof. Hyatt's sketches[7] represent two stages of development in the life history of this remarkable hydroid. One of these [Fig. 3] is evidently of a younger and less developed animal, possessing temporary tentacles which have a likeness to those figured by Allman in the immature Myriothela. We know from Allman that as the Myriothela grows older, the tentacles, which in this genus are known to belong to larval life, disappear, and are lost in the adult. These are represented in our figure [Fig. 3] on the axis, about one-third the length of the young Acaulis, while the remainder of the body bears simply suckers, which cover the surface of this region of its body. In the second figure [Figs. 1 and 2], which represents a larger individual, and one which is therefore probably more mature, two regions can be readily distinguished in the body, which we may call an anterior and a posterior body-region. The animal is represented as attached to a shell by suckers at the anterior end,—the broken parts of these organs are represented by dotted lines, as these appendages have been ruptured. In Prof. Hyatt's notes, brown matter is mentioned as being found at the place of adhesion of these suckers to the foreign body.

For a short portion of the body adjoining the terminal tentacles its surface is thrown into folds or ridges (*f*), which are possibly due to mural contraction. From this region there arise botryoidal bodies, which are supposed to be gonophores (*g*) or homologous structures, each of which has, according to the notes, a dark purple interior and a granular whitish exterior wall. The remainder

[7] Stimpson's figures of Acaulis are the only ones yet published of this highly exceptional hydroid.

of the body narrows gradually to its so-called posterior end, throughout which it is covered with closely crowded, wen-like structures of a light pink color. The interior of this region of the body is dark purple, and there is, according to the notes, a terminal orifice (*a*).

It will be noticed in reviewing Stimpson's account, and comparing his figures with those here published, that he also describes two successive stages of development which correspond closely with those which I have figured. The "tentacula" in the anterior region of one of those given are larger at the blunt extremity of the body, while the gonophores are in an advanced stage of development. In this stage of growth, organs which are called the "inferior appendages" by Stimpson had disappeared. The stage last mentioned is supposed to be the adult, or at all events to be older than the other form which he figures. By comparing it with the adult of Myriothela, as figured by Hincks and Allman, this conclusion seems to be tenable.

If now we turn to the two similar stages shown in the figures, which we here have given, it will be found that the older (Fig. 1), differs from the younger in the same way that the "adult" in those by Stimpson differs from what he considers the young. Possibly the most important difference in each case between the two stages is the loss, in the adult, of the temporary tentacles found in the young.

There have been several opinions expressed as to the relationships of the Acaulis. It has been called a free-swimming hydroid, and associated with the supposed free hydroid of Nemopsis,[8] mentioned by McCrady. It has also been likened to a head of a Tubularian ruptured from a hydroid stem. The true affinities have been conjectured by several naturalists, but so little has been made known of the anatomy of Acaulis that it has been difficult to compare it with other hydroids.

Hincks,[9] in discussing the relationship of Acaulis and Myriothela, says "Mr. Alder has suggested the probability of a close affinity between Myriothela and the Acaulis of Stimpson, and

[8] The young of Nemopsis has been shown to have a fixed hydroid.

[9] A History of British Hydroids, pp. 76, 77.

would place it in the family of the Tubularidæ. To this view I am unable to assent, although it has received a certain measure of support from Prof. Allman. The Acaulis is furnished at first with a verticil of filiform tentacles near the base of the polypite (though

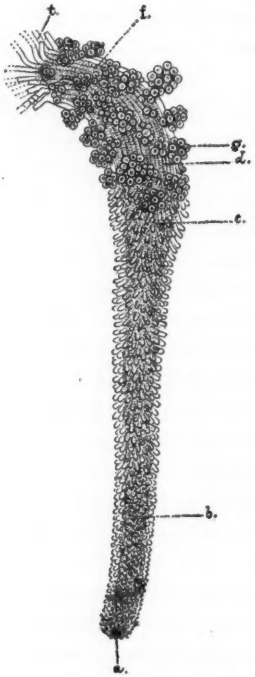


FIG. 1.—Adult Acaulis. *a*, terminal opening of the body—the interior of this body is "dark reddish purple"; *b*, central, purple-colored body wall; *c*, small papillæ—these, as well as the external body wall, are light pink; *d*, ridges or folds in the external walls of the body, of a "white color"; *e*, terminal continuation (unattached) of the body of the young Acaulis. *g*, gonophores—the interior of these clusters is dark purple; the exterior, white granular; *t*, permanent tentacles—"suctorial tentacles"; *tt*, temporary tentacles.

they are said to disappear subsequently), and between these and the upper capitate tentacles the reproductive buds are developed on the body. But Myriothela, so far as we know, is destitute of basal tentacles at all stages of its existence, and the gonophores,

instead of being borne on simple or branched pedicles, as in the Tubularidæ, are produced on distinct coryniform zooids—small, rudimentary polypites, which are homologous with the so-called gonoblastidia of Hydractinia or Dicoryne. It is, as I have said before, a cluster of polypites nearly related to Coryne; but its marked peculiarities would seem to entitle it to stand as the type of a special family."

The author would here offer the following generalization to which he has been led by the consideration of two facts exhibited in the characters of the animal above described. First, the basal cirri of the first stage are homologous to the lower or exterior tentacula of Tubularia. Secondly, these cirri, or tentacula, are lost [10] with the growth of the animal, and do not appear in the second stage. Hence we should consider the Tubularidæ, in which they are persistent, as lower in the scale. It might add some weight to this conclusion to call attention to the fact that the medusæ of Tubularia assume the form of Actinulæ, in which we have a remote resemblance to the young Acaulis.

It may be deduced, also, from the above account that the species just described, having basal tentacula, is more embryonic than Coryne and its allies, in which they never appear, so that it is correctly classed between that genus and Tubularia; and if, as is possible, the single circle of tentacula in the Sertularidæ is homologous with the basal tentacula of Acaulis and Tubularia, it would follow that that family should stand lower in an ascending scale of classification. The disappearance of the verticil of filiform tentacles in Acaulis is certainly not an objection to considering this genus as allied to Myriothela, especially since the account which Allman gives of the embryology of Myriothela, published subsequently to Hincks's "History of British Hydroids," shows that Myriothela has these or similar tentacles.[11]

[10] In regard to Hincks' dissent from Prof. Allman's opinion in regard to the affinities of Myriothela, and the grounds of his objection, it is only necessary to refer to Allman's Embryology of Myriothela, which to my mind effectually answers all objections as far as the supposed want of "basal tentacles at all stages of existence" goes. I believe, however, with Hincks, that Myriothela has such marked peculiarities that they "seem to entitle it to stand as a type for a special family."

[11] Probably absorbed, not deciduous.

It seems possible to take another view of the homology of the temporary or embryonic tentacles in the former stage of Acaulis than that suggested above. In the first place, we may regard them as the same as the temporary tentacles of the young Myriothela. They are in point of fact not unlike similar appendages in Actinula, with which they may be readily homologized. Somewhat similar temporary appendages appear in the young Glossocodon on the side of the bell, as have been described by others, and as I have figured in my paper on the Tortugas Acalephæ. If we regard the Actinula as represented by the young Glossocodon it seems possible that the temporary appendages in both may be homologous. It seems to me probable that there is a close likeness between the young Myriothela, as represented by Allman, and an Actinula in the smaller of the two kinds of specimens which are here figured.

It is on account of the embryonic likeness of Myriothela that in my plates of the Hydrozoa in the Embryological Monographs (Memoirs Museum Comp. Zoology, Vol. IX., No. 3.) I placed Myriothela in close proximity with Hydra among the lowest forms of these animals. Still, in certain features, Myriothela has a high organization which is shared also by Acaulis. It would be interesting and valuable from a morphological standpoint to know more of the ultimate form of the body and appendages of Acaulis, and some of the early stages in growth which lie between the ovum and the young with temporary tentacles.

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BY J. S. KINGSLEY.

(*Continued from Vol. XXIV., p. 357.*)

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EROSIVE AGENTS IN THE ARID REGIONS.

BY RALPH S. TARR.

AMONG the mountains in the western part of the United States the agents of erosion are not unlike those of the moister sections of the east. Rain, snow, ice and frost are the chief factors in the sculpturing of these mountain masses.

On the plateau the conditions are different. Snow and ice are rarely seen; frost seldom appears, owing to the extreme dryness of the atmosphere, and rain falls under peculiar conditions. In all climates the action of animals and plants, of sun and air, are important factors in the wearing away of land masses; but in few places are the effects of these agents so important as in the western plateau region. Most if not all the agents of erosion which I shall describe have been noticed and mentioned by the various writers on the geology of the arid regions; but their importance seems so great that it may be well to group them and call especial attention to them.

Of the physical agents, as in all sections of the world, except the most arid, rain is the chief. For fully nine months in the year little or no rain falls upon the truly arid belt. When, during these months, rain falls at all, it comes simply as light showers or brief drizzling rain, producing almost no geological effect. It is absorbed by the soil, and is rarely in sufficient quantity to freshen the parched vegetation.

During the three summer months the region is liable to excessive local rains, often called "cloud-bursts." Several inches frequently fall in an hour during such a shower. Two-thirds of the annual precipitation falls in a few such rains. The geological effect of so much water suddenly poured upon the ground is intense. The whole soil is completely wetted for a depth of several feet, and even in this dry region torrents flow tumultously to the streams. The arid plateaux are chiefly regions of young drainage, on which there are large tracts without drainage arteries.

When a cloud-burst falls upon such a place deep ravines or "arroy s" are suddenly formed by the rush of the waters. Sometimes an "arroyá" fifteen feet deep is cut out in the soil for a distance of a mile. The destructive effects of such a cloud-burst are great, particularly when it breaks upon high ground and flows upon a plain. In July, 1886, I witnessed the effects of such a torrent in the Rio Grande Valley, in New Mexico. The cloud-burst broke upon the low Donna Anna mountains, but no rain fell outside of their limits. The mountains were capped by a dark thunder cloud, while in the valley at Donna Anna, about six miles distant, the sky was cloudless. In a short time a wall of muddy water a foot high spread over the flood plain of the Rio Grande near Donna Anna, and this was followed by similar waves for a half-hour. At Donna Anna, which is situated on a bluff bounded on the south by an "arroyá," a body of water completely filling the arroyá was seen to pass by for about a half-hour, then the body of water gradually diminished to a trickling stream, and in less than an hour no water was flowing. The depth of water must have been twenty feet at this point. It cut under the cliff on which Donna Anna is built, and scaled off a large piece, leaving a house on the edge of a precipitous wall. The stream carried vast quantities of bushes, roots and clay, and, I am told, some animals. On the flood plain several acres of vineyard were completely covered with silt and gravel, one or two small orchards were partially buried, and an adobe house about ten feet high was buried to within two feet of the top. Several thousand tons of earth must have been removed during this torrent. Such floods are not uncommon in these arid regions, and their intense erosive activity may be seen by this illustration.

Next in importance to rain is the direct effect of the air as an erosive agent. In many places in the arid territories extensive sand dunes are proofs of this æolian action; but these are merely grand illustrations of a common phenomenon. During all months of the year dust is being blown about either in clouds or in creeping waves along the surface of the ground. In the valley of the lower Rio Grande, in New Mexico, often for several

days in succession strong winds blow clouds of dust along the mesa, and these are often so dense that the Oregon Mountains, ordinarily plainly visible, are completely obscured from view. On the upper Rio Grande, at Embudo, in March, 1889, clouds of dust not uncommonly swept up the cañon, obscuring the high canyon walls from view, although they were only a mile distant. In February of the same year I encountered a dust storm in the pass among the White Mountains, near Fort Stanton, New Mexico, which lasted for several hours. The wind was blowing at a velocity of sixty miles an hour, and not only sand but small bits of gravel were blown with such force as to produce a painful blow on the face. The road could not be seen for a distance of twenty feet. Fine particles of dust penetrated to the works of my watch and caused it to stop.

Another common phenomenon of aerial erosion is the formation of small whirlwinds, to be seen on all sides on the plateau during the summer time. These sometimes gather force enough to carry away small bushes. The creeping action of blowing sand I have often had forcibly illustrated, when during a windy night the sand has blown upon my blankets, and formed a thin coating of sand.

The direct effect of change in temperature must be an important geological agent. On the plains the temperature of the sand is often 115° during mid-day, while in the early morning it may be as low as 60°. During the winter a black bulb thermometer registered 105° at one o'clock, while the minimum temperature at night was 27°. Such an excessive thermometric range must aid greatly in breaking up the rocks, especially the black basalts so common in the west.

Organic aids to erosion are also important. Plants serve very slightly in breaking up the soil. They grow with extreme slowness and great difficulty. They are important more in a conservative than a destructive way. The vegetation is thin and scanty, and hence does not act as a protective covering to the extent that plants of a moister climate do. The conservative effect is well shown, however, in the case of the mesquite, which catches and holds down the blowing sand, and as a result often

causes to be built around it a bank of sand many feet high, often fifteen or twenty feet. The mesquite, and indeed almost all arid land-plants, have great root extension, by far the greater part of the plant being beneath ground, and the disintergrating offect of this peculiarity must be considered.

Among animals there are at least three types which are doing much work of erosion. Formerly the bison, and now their successors,—cattle,—have done an appreciable geological work. In the formation of trails and the general tramping of the ground they have aided in protecting the soil against the action of wind and water. Recently in southern New Mexico, on the Pecos, I have had my attention forcibly called to the importance of cattle in this direction. Several small streams had their course considerably lengthened by the puddling of the stream-bed by cattle.

Ants are very abundant on the plateau, and they are continually at work tunnelling the soil and bringing fresh earth to the surface. On the upper Rio Grand, near Embudo, there is a clayey gravel containing many small garnets. The ant-hills in the vicinity are composed chiefly of garnets. The clay is apparently washed out, and the coarser particles have remained. Ant-hills are frequently washed away during a rain, but they are quickly rebuilt. A peculiar ant, the "agricultural ant," so called, is common in the south-west. These creatures have a clear space around their homes, thus exposing the bare ground to the action of the elements.

The work done by prairie dogs, while in individual cases apparently insignificant, must amount to a grand sum total. Over large tracts their burrows open to the air at intervals averaging not more than twenty-five feet apart. I have no means of telling how far they extend into the ground, but from the appearance of their mounds I should judge it to be only a few feet. This mound rarely exceeds a height of two feet, and generally less. Being in the form of a truncated cone, with a very gradual slope; they are sometimes three feet in diameter. Their burrow is seldom more than six inches wide, so that its extreme length cannot be many feet. That the creatures are constantly at work is

proved by the great number of new holes in every "dog town," and also by the number of holes in old roads passing through sections inhabited by the prairie dog. Deserted burrows can always be told by the destruction of the mound, and widening of the hole under the influence of subaerial denudation. The towns are generally built on gentle sloping hills, where there is some drainage, consequently the fresh clay and earth brought to the surface is gradually drifted away. Not only is the work of erosion aided by the bringing up of material to the surface, but also by the opening of tunnels, by which water is allowed free underground passage. With a mound around the hole this inflowing of water is reduced to a minimum; but when the hole is abandoned, and the mound destroyed, water freely enters, and in such cases I have frequently noticed small runlets leading to the hole.

Thus it will be seen that the great agent of erosion, water, is of particular importance in the arid regions on account of its intensified action during brief periods; that the direct effect of aerial currents is a powerful factor in the erosion of these plateaux; that the sun's heat must also play an important part; that plants are only slightly conservative and slightly destructive; and that animals, by tramping down the soil or by burrowing and tunneling into the earth, are important aids in the great work of subaerial denudation by which the plateaux of the west are being gradually eaten away.

EDITORIAL.

EDITORS, E. D. COPE AND J. S. KINGSLEY.

THE U. S. National Academy of Sciences is entertaining a proposition to divide its membership into classes. These are ten in number in the plan, as follows: Mathematics, Physics, Astronomy, Geodesy and Mechanics, Chemistry, Geology, Botany, Zoölogy, Anthropology, and Political Economy and Statistics.

A classification of the sciences which shall be consistent with their nature and relations is of course difficult, and the above arrangement may be criticised, especially on the part of biologists. It is, however, reasonable that physiology, embryology and paleontology should be relegated to botany and zoology respectively. But psychology cannot be properly so referred, and its omission is a defect in the plan which it is important to remedy.

We believe that such a division into classes will be useful in directing attention to possible deficiency or excess in the representation of the various branches of science. But it must be borne in mind on the other hand that no equality of representation will be possible, and the departments, if adopted, will be filled as nearly as possible in accordance with the number of deserving candidates which can be found.

In order to secure a more equal and just representation, another plan of division was proposed some years ago which was not adopted. Four classes were recommended, viz.: Psychology, Physics, Natural History and Applied Science. It was proposed to give to the first and last-named classes fifteen members each, and to the second and third, which would correspond with the old sections A and B of the American Association for the Advancement of Science, thirty-five members each. This may be a better scheme than the one now before the Academy.

The new plan proposes that any of the classes may be called together and hold meetings to consider questions relating to their departments. This is a proposition to be considered with care. Occasions requiring such separate action will be rare, and per-

haps had better be deferred until meetings of the entire Academy can be had. It is doubtful whether such a plan would be productive of advantage to the Academy. We hope also that the division into classes will not be made a pretext for increasing the membership to above one hundred persons.

—THE last meeting of the Committee of Arrangements for the reception of the International Congress of Geologists was held in Washington, D. C., April 18th. The American Committee had, on the occasion of their last Congress (in London), presented the invitation of a number of Philadelphia organizations and officials to the Congress to hold its next session in Philadelphia, which invitation was accepted by the Bureau of Direction on behalf of the Congress. Some uncertainty remained as to the best time of holding the Congress, owing to the fact that the Jubilee of the University of Pennsylvania and the International Exposition at Chicago had both been postponed from the original dates, and it was thought to be important that the Congress should coincide with one or the other of these events. The committee, however, voted that the meeting of Congress should be held in 1891, thus allowing but little time for preparations. This premature action might have been harmless, however, but for the subsequent action by which it was voted to ask the Bureau to transfer the place of meeting from Philadelphia to Washington. The time required to get the consent of the Bureau, whose members live in many countries and at remote distances, will be so great as to prevent the proper preparation for the Congress, owing to the lack of time. This conclusion was reached principally by the votes of active or past employees of the U. S. Geological Survey on motions made by the Director of the Survey (Major J. W. Powell), who constituted a majority of the Committee; one member of the Survey, Capt. C. E. Dutton, not voting. The adoption of the motions of Major Powell is equivalent to the destruction of the international character of the Congress. The object of the Director in bringing about this result may be well imagined. That he should have the support of the International Congress of Geologists is no doubt a very desirable consummation for the Director of the

Survey, since he has not hitherto experienced any especial recognition from that body. And that he shall have such recognition from a body controlled by himself, is a foregone conclusion. There are, however, many American geologists who think that this International Congress should not be used to advance the political aspirations of Major Powell. We are of this number, and we therefore hope that the Bureau of Europe will not accede to the request of the majority of the Committee, but will adhere to their original decision that the Congress be held in Philadelphia, where it will have a truly international character, and be free from the domination of any particular body. The date also should be postponed until 1892, in order to allow the time requisite for preparation, and to coincide with the approaching Jubilee of the University of Pennsylvania. The facilities for holding the Congress in Philadelphia are excellent, and they will be made fully available by the coöperation of the Philadelphia members of the Committee of Reception.

—THE scientific men of Indiana are preparing to give the American Association for the Advancement of Science a warm welcome at Indianapolis the coming summer. If their efforts meet with the relative success that they did at the first meeting of the Association at that city in 1871, the Association will have occasion to congratulate itself. We hope however that the local committee will arrange that the excursions be postponed until after the close of the meetings so that the real business may not be interfered with too seriously. Indiana includes within its borders more original investigators in science than any state west of the Allegheny Mountains, and we have no doubt but that the interests of science will be well cared for at their hands.

General Notes.

GEOGRAPHY AND TRAVELS.

Col. Stanton's Recent Descent of the Colorado River.—Col. Robert Stanton, commander of the Denver expedition now exploring the comparatively unknown regions traversed by the Colorado river, has written to the Denver *Republican* a graphic account of the perilous journey down the wild stream from the head of the Granite gorge of the Grand canyon to the mouth of Diamond creek, to accomplish which required the time from January 24 to March 1. The expedition had to battle upon entering the Granite gorge with mighty cataracts and foaming torrents, sometimes letting their boats down with ropes, and at times portaging all the contents of the boats around rapids. Two of the boats were dashed against rocks and wrecked. Progress was extremely slow. At one point they were delayed five days while one of the wrecked boats was being reconstructed. Of that portion of the Granite gorge from its head to Bright Angel creek, Col. Stanton quotes from his note book, under date of February 7:

"The canyon is growing more and more picturesque and beautiful the further we proceed. The Granite has lost its awful and threatening look, and slopes back in beautiful hillsides of variegated black, gray, and green. Above this, next to the river, is a stratum of dark sandstone cut into sharp horizontal layers, standing in an almost perpendicular wall, jutting out in places to the edge of the granite, and studded all over with points standing out in the air, darker in color than those behind them, and the top edge cut into smaller points and crevices through which the light shines, giving a rough, beaded appearance.

VIEWS IN THE GORGE.

"At the side of the canyons, and from the bends of the river, the upper portions of the whole gorge are brought into view, showing the great marble and sandstone cliffs benched back far away from the river, while small mountains jut in close between the side canyons and wash nearly a mile and a quarter in height. As we sail along the smooth stretches between the rapids each turn brings some wonderful picture more beautiful than the last. As we look down the river or up a low side canyon, with the placid water between its polished walls of black

and gray and green for a foreground, there rises above the dark sandstone tier upon tier, bencn upon bench, terrace upon terrace, stepping back further and further and higher and higher, and in their immensity of height and proportions seeming to tower almost over our heads. First above the darker sandstone come the flattened slopes of the line, and mineralized matter in horizontal layers of yellow, brown, white, red, and green.

"Then rise sheer walls of stained marble 1,000 feet or more, the lower portions yellow, brown, and red, and the coloring of red growing brighter as it nears the top. Above this, smaller benches of marble, at the top of each a little mesa covered with green grass and brushes, and above these a dozen or more terraces of scarlet and flame-colored sandstone, stained on their outer points with black, and the little benches between them relieved by the bright green of the grease-wood and bunch grass, the whole covered with, perhaps, a couple of thousand feet of the lighter gray, yellow, and white sandstone ledges, capped by pinnacles and spires, turrets and domes in every imaginable shape, size and proportion, with all their slopes covered and their tops fringed with pine, cedar, and pinion trees, whose bright green stands out in bold relief against the flaming colors of the sandstone, and the banks of pure white snow that cover the top and have run down into the many gulches along the sides."

A CHANGE IN THE SCENE.

Further on he writes: "From the southern portion of Powell's plateau to the mouth of the Kanab Wash the canyon assumes an entirely new form. The granite, except in a few patches, has sunk under the river, and the softer strata of sand and limestone which formed the great slopes above the granite have come down next to the river and rise from the water's edge in great talus slopes of from 300 to 600 feet high at a general angle of 40 degrees from vertical. The high cliffs of marble and red sandstone bench back from the top of these slopes. Although these outer peaks and cliffs have drawn in close upon the river the canyon itself—that is the inner gorge—is much wider than above, the width being measured between the tops of the great talus slopes. The river is broader, and it sweeps in gentle curves at the foot of the talus, which is covered with bushes, bunch grass, and large mesquite groves. On many of the long stretches where the river can be seen for several miles the picture is one of grandeur and beauty. Grand with its walls of bright colors towering 2,500 feet overhead, beautiful in its long green slopes, with the quiet waters sparkling

in the sun at their foot, for the rapids are much less frequent, and stretches of still water are growing longer and longer.

"From the mouth of the Kanab Wash for about twenty miles down is perhaps the narrowest and deepest part of the great inner gorge. The lovely sandstone and limestone ledges have sunken under the river, and the marble and upper sandstones come close into the water. At the bottom the gorge is from 150 to 200 feet wide, and the river runs between vertical walls—vertical, however, for only about 80 feet up—and fills the whole space from wall to wall. The walls of this portion of the canyon—(and it comes nearer being a true canyon than any other part of the river)—rise above the water 3,000 feet, and they are almost vertical; the benches are narrower, and the vertical cliffs between the benches higher than in any other section. And yet, strange to relate, from one end of this section to the other there is a bench about 50 feet above high water, running almost parallel with the grade of the river, of solid marble wide enough to build a four-track railroad upon and not interfere with the perpendicular walls above or the river below.

IN FLOOD AND RAPID.

"The night before we reached Kanab the river rose four feet; it continued to rise for two days and two nights. How much the rise was I am not absolutely certain, but believe from good evidence it was fully ten feet. Just below Kanab Wash there is a rapid one and one-half miles long. On Tuesday morning we started down this rapid. We made this mile and a half in just four and one-half minutes. We then had for some time few rapids, but a rushing, singing current, forming eddies, whirlpools and back currents fearful to contemplate, much more to ride upon.

"About 2:30 p. m. we heard a deep, loud roar and saw the breakers ahead in white foam. With a great effort we stopped upon a pile of broken rocks that had rolled into the river. Much to our surprise when we went to look, the whole terrible rapid that we had expected to see had disappeared, and only a rushing current in its stead. While we stood wondering there rose right at our feet those same great waves, 12 to 14 feet in height and 100 to 150 feet long across the river, rolling down stream like great sea waves, and breaking in white foam with a terrible noise. We watched and wondered and at last concluded this was the fore front of a great body of water rolling down this narrow trough from some great cloudburst above. Believing that discretion was the better part of valor, we camped right there on that pile of rocks, fearing that although our boats would ride these waves in safety,

we might be caught in one of these rolls just at the head of a rapid, and, unable to stop, be carried over the rapid with the additional force of these rushing breakers.

"The next morning, to our surprise, we found the flood had begun to recede. After an early breakfast we started on what afterwards proved to be the wildest, most daring and exciting ride we have had on the river. The canyon so narrow, the turns quick and sharp, the current rushing first on one side and then on the other, forming whirlpools, eddies and chutes, our boats caught first in one and then in the other, now spun around like leaves in the wind, then shot far to the right or left almost against the wall, now caught by a mighty roll and first carried to the top of the great waves, and then dropped into the 'trough of the sea,' with a force almost sufficient to take away one's breath, many times narrowly escaping being carried over the rapids before we could examine them, making exciting and sudden landings by pulling close to shore, and with bow up stream rowing hard to partially check our speed, while one man jumps with a line to a little ledge of rocks and holds on for his life and ours too.

A STRUGGLE FOR LIFE.

"At last the expected combination comes. We round a sharp turn and see a roaring, foaming rapid below, and as we come in full view of it we are caught in a mighty roll of flood wave.

"We try to pull out to an eddy—it is all in vain; we cannot cross such a current. We must go down over the rapid. In trying to pull out we got our boats quartering with the current, over the rollers and through the breakers up to the head of the rapid. In this position they travel a course, first in the air and then in the water, only to be compared to the spirals of a corkscrew. When we find we must go over the rapid, with great effort we straighten them round and enter in good shape, bow on. It lasts but a moment, the cross current strikes us and we are turned, go broadside down over the worst part of the rapid (which proves clear of rocks), then, turned and twisted about, we go through the rest of the fall in wild, wizard waltz, to music more weird than that of the bagpipe. At the end of the fall our sturdy boats float out into an eddy as quietly and gracefully as swans. Noble little crafts! May they, the Bonnie Jean and Lillie, live long enough to float on more peaceful waters than those of the Colorado river, over whose rushing torrents they have glided now near 500 miles and never once been upset. And peace be to the ashes (I should say splints) of the sweet Marie that we left in the dark canyon above."—*The Evening Star, Washington, D. C.*

GEOLOGY AND PALEONTOLOGY.

The Strength of the Earth's Crust.—The term crust is here used to indicate the outside part of the earth, without reference to the question whether it differs in constitution from the interior.

Conceive a large tank of paraffine with level surface. If a hole be dug in this and the material be piled in a heap at one side, the permanence of hole or heap will depend on its magnitude. Beyond a certain limit, further investigation and heaping will be completely compensated by the flow of the material. Substitute for paraffine the material of the earth's crust, and the same results will follow, but the limiting size of the hole or heap will be different, because the strength of the material is not the same. Assuming the earth to be homogeneous, the greatest possible stable prominence or depression is a measure of the strength of its material.

It is not believed that the earth is homogeneous, and with reference to the outer portion of the crust it is known that it is not composed of homogeneous shells. There is observational basis for the theory that the matter composing and lying beneath ocean beds and continents is lighter than the matter composing and lying beneath ocean beds, and many students of terrestrial physics entertain the theory that unit columns extending from the surface downward have everywhere the same weight, the height of each column being inversely as its mean density. In accordance with this theory, prominences and depressions of the surface exist in virtue of a principle of equilibrium, called isostatic.[1] Under hydrostatic equilibrium the surface of a free liquid is level; under isostatic equilibrium the surface of a non-homogeneous solid capable of viscous flow, is uneven.

There are thus two possible explanations of the inequalities of terrestrial surface, and these may be characterized severally by the terms rigidity and isostasy.

In connection with a study of Lake Bonneville, a large body of water temporarily filling a basin of Utah during Pleistocene time,[2] observational data were gathered bearing on the question of rigidity versus isostasy.

[1] For definitions of the new term "isostasy" and its adjective "isostatic," see Dut. ton in Bull. Phil. Soc., Washington, XI., p. 53, and Woodward in *Am. Jour. Sci.*, 3d Series, Vol. XXXVIII, 1889, p. 351.

[2] An account of Lake Bonneville may be found in the Second Annual Report of the U. S. Geological Survey, 1881, pp. 167-200.

1. The Wasatch mountain range is carved from a large block of crustal material, uplifted along a fault plane at one side. The block adjoining the fault plane on the opposite side is thrown down. Erosion s continually transferring material from the uplifted block to the down-thrown block, and there is direct evidence that the mountain is steadily rising or the valley sinking, or both. Some advocates of the isostatic theory would regard this progressive relative displacement as a direct effect of the continual transfer of load. Under this view the mountain block has less density than the valley block, and the two are in isostatic equilibrium; the unloading of the mountain block by erosion and the loading of the valley block by deposition disturb the equilibrium, and it is restored by vertical movement on the fault plane.

An arm of Lake Bonneville occupied the valley, filling it to an average depth of 500 or 600 feet, and this load of water was somewhat quickly added and afterward somewhat quickly removed. If the valley block were delicately sensitive to the application of load, it should be depressed about 200 feet by the access of water, and should rise a corresponding amount when the water was removed. But this did not occur. On the contrary, the depression of the valley, as shown by changes occurring along the fault plane, continued alike during the presence of the water and after its removal. It is therefore concluded that the local transfer of load from one orognic block to the other is not the primary cause of the progressive rise of the mountain and depression of the valley, and the question arises whether the mountain range may not be wholly sustained in virtue of rigidity.

2. Considering the main body of Lake Bonneville, it appears from a study of the shorelines that the removal of the water was accompanied, or accompanied and followed, by the uprising of the central part of the basin. The coincidence of the phenomena may have been fortuitous, or the unloading may have been the cause of the uprising. Postulating the casual relation, and assuming that isostatic equilibrium, disturbed by the removal of the water, was restored by viscous flow of crust matter, then it appears (from the observational data[3]) that the flow was not quantitatively sufficient to satisfy the stresses created by the unloading. A stress residium was left to be taken up by rigidity, and the measure of this residium is equivalent to the weight of from 400 to 600 cubic miles of rock.

From these phenomena and theoretic considerations arises the

[3] These data are not yet fully published, but will appear in a memoir on Lake Bonneville now in press, constituting Vol. I. of the Monographs of the U. S. Geological Survey.

working hypothesis that the measure of the strength of the crust is a prominence or a concavity about 600 cubic miles in volume.

If this hypothesis is strictly true, then there should be no single mountain mass and no single valley, due purely to the local addition or subtraction of material, having a greater volume than 600 cubic miles. At least four kinds of mountains and valleys are due simply to the addition and subtraction of material: (1) mountains of extravasation (such as volcanic cones), beneath which the pre-existent terranes lie undisturbed; (2) mountains of circumdenudation, produced by the removal of surrounding material; (3) mountains produced by extravasation *and* circumdenudation; (4) valleys of erosion, unaccompanied by phenomena of displacement.

A large number of such mountains and valleys exist, and some of the largest occurring in the United States have been mapped in contours by the U. S. Geological Survey, so that their volumes can be computed readily.

San Francisco Mt., in Arizona, a result of extravasation, has a volume of 40 cubic miles.

Mt. Shasta, probably due to extravasation only, has a volume of 80 cubic miles.

The Tavaputs Plateau, or Roan Mt., lying on the borders of Utah and Colorado, and produced by circumdenudation, has a volume of 700 cubic miles.

Mt. Taylor, and the Taylor Plateau, in New Mexico, resulting from extravasation and circumdenudation, have jointly a volume of 190 cubic miles.

The Henry Mts., resulting from volcanic intrusion and circumdenudation, have a volume of 230 cubic miles.

The Sierra La Sal, a mountain group of the same type, has a volume of 250 cubic miles.

The deeper portion of the Grand Cañon from the Colorado, from the mouth of the Little Colorado to the mouth of Kanab Creek, is due to the removal of 350 cubic miles of rock.

The Tavaputs Plateau slightly exceeds the hypothetic limit; the other illustrations fall within it.

In view of the phenomena cited, and of the considerations and comparisons adduced, it is believed that the following theorem or working hypothesis is worthy of consideration and of comparison with additional facts: *Mountains, mountain ranges, and valleys of magnitude equivalent to mountains, exist generally in virtue of the rigidity of the earth's crust; continents, continental plateaus, and oceanic basins exist*

in virtue of isostatic equilibrium in a crust heterogeneous as to density.— G. K. GILBERT, in *Bulletin. Geol. Soc. America.*

Scott and Osborn on the Fauna of the Brown's Park Eocene.[1]—This memoir supplies an important desideratum, since we obtain through it the first intelligible view of the Mammalian fauna of the Brown's Park or Uinta (name preoccupied) horizon of the Eocene of North America. This formation, as is well known, occupies the summit of the Eocene series, and therefore intervenes between the Bridger below and the White-River above. The faunæ of the last-named horizons are tolerably well known, while for the Brown's Park series we have had to depend hitherto on the exceedingly unsatisfactory descriptions published by Marsh many years ago. The formation has, so far as known, a limited geographical extent, occurring at the south base of the Uinta Mountains in N. E. Utah only. This location was explored by the Princeton party under Professor W. B. Scott, whose observations on the geology constitute the introduction to this memoir.

The paleontological part of the memoir is an excellent model of what such a work ought to be, and the results are worthy of the care bestowed on its preparation. The species observed are eleven in number, which belong to as many genera. These are as follows: *Quadrumana,* Hyopsodus; *Glires,* Plesiarctomys; *Creodonta,* Mesonyx and Miacis; *Perissodactyla,* Epihippus, Diplacodon, Isectolophus, Amynodon and Triplopus; *Artiodactyla,* Protoreodon and Leptotragulus. Of these genera, Isectolophus, Protoreodon, and Leptotragulus were discovered by the Princeton expedition. Nothing of unusual novelty is stated with regard to the species and genera of the Quadrumana, Glires, and Creodonta, but the case is quite different with regard to the Ungulata. Ancestral forms of later types are here most distinctly indicated, and the authors must be congratulated on the important contribution they have thus made to the doctrine of evolution. They show that Epihippus stands in the line of the horses, as asserted by Marsh, but, unlike that author, they satisfactorily demonstrate that it intervenes between Pliolophus and Anchitherium. They also show that Diplacodon is the ancestor of the varied forms of the Menodontidæ of the lower Miocene, and the descendant of Palacosyops of the Bridger Eocene. Isectolophus is proven to be the parent of the tapirs, connecting that

[1] The Mammalia of the Uinta Formation. Part I., The Geological and Faunal Relations, and Part II., the Creodonta, Rodentia and Artiodactyla, by W. B. Scott; Part III., The Perissodactyla, and Part IV., The Evolution of the Ungulate Foot, by H. F. Osborn. Transactions of the American Philosophical Society, Philadelphia, 1889, Vol. XVI., p. 461; pl. v.; p. 112.

type with Systemodon, through some intermediate forms, as suggested by the present writer.[2] Amynodon is fully elucidated as far as cranial structure goes, and its relation to the primitive rhinoceroses pointed out. A new Triplopus (*T. obliquidens* S. & O.) is described, which is of larger size than the *T. cubitalis* of the Bridger, and the knowledge of the character of the genus is increased. Protoreodon S. & O. is of especial interest. It is essentially an Oreodont with the fifth crescent (metaconule) of the superior molar present as in the Eocene Artiodactyla generally. It is so much like Oreodon in other respects as to indicate its place as ancestral to that form, and it adds one more piece of evidence to sustain the view that the tetraselenodont forms are the descendants of the pentaselenodont Artiodactyla. The *Protoreodon parvus* S. & O. was an animal about the size of a raccoon. Leptotragulus is an equally interesting form, since it supplies the hitherto missing ancestor of Poëbrotherium. It is tetraselenodont, and differs chiefly from the latter and later genus in the freedom of the ulna and radius from each other. Thus the genera of Ungulata of this formation extend the phylogenetic lines by one period backwards, or they fill gaps hypothetically awaiting occupation.

The chapter on the evolution of the Ungulate foot, by Prof. Osborn, handles the subject in a masterly way. The author admits the fundamental propriety of the system proposed by Cope, but takes some exception to an application of it in detail in certain directions. The exception on which most stress is laid is the fact that in the equine line, after the development of diplarthry in the posterior foot, a tendency to revert to taxeopody appears. Prof. Osborn states that the above-mentioned system becomes here "not strictly applicable;" but as he has not demonstrated a return to absolute taxeopody, and as he admits the fundamental conformity of the system to nature, the objection cannot be said to have much weight. The condition in Equus shows only the effect of the increased dimensions of the median digit and the corresponding elements of the second tarsal row, to which the first tarsal row does not fully correspond.

Prof. Osborn also objects to Cope's theory of the origin of diplarthry by torsion, stating with reason that were this the only movement, the metarso-tarsal articulation cannot be accounted for. In other words, were the tarsus and carpus to be rotated externally on the metatarsus and metacarpus, dislocation of their articulation would take place. Prof. Osborn called my attention verbally to this point, and as I had not previously considered it, I supplied what I thought to be an ade-

[2] Article Perissodactyla, AMER. NATURALIST, 1887, December.

quate explanation in my late memoir in *The American Journal of Morphology*.[3] This was based on the fact already recorded by Allen in his analysis of the Muybridge photographs, that in recover the weight is borne on the inner edge of the foot, and therefore on the external sides of the heads of the metapodials. I did not then state with sufficient clearness what I now add, that the external torsion of the lower leg concerned in producing diplarthry is that which occurs, as I have pointed out, at recover, and it is therefore coincident in time with the transfer of the weight to the inner side of the foot, so that both strains occur together, and so dislocation cannot occur. In rapid movement, when the torsion-strain is most energetic, all the strains will be nearly contemporaneous; while in slow movements the torsion on plantation will be distinct, if existing, of which there is some doubt. Thus is directed and located the growth-energy, to which Prof. Osborn appeals as a sufficient explanation of the phenomenon of diplarthry.

The authors in a few instances, through some oversight, have misstated the opinions of the present reviewer. Thus Prof. Scott cites him as having regarded the genera Amynodon and Metamynodon as identical. This he has not done, as can be seen by his systematic descriptions of the two genera in "The Perissodactyla," (NATURALIST, 1887, p. 993). Prof. Osborn quotes my earlier proposition of 1885, that Triplopus is in the phylum of the rhinoceroses, and omits to mention the modified view expressed in "The Perissodactyla" (1888), that it is in the line of Hyracodon, and at one side of the rhinoceroses. The slender legs of the known species of this genus are, however, not to be regarded as a generic character, as is done by Osborn, and a stout-legged Triplopus is by no means an impossibility. Finally, Osborn accuses me of regarding carpal and tarsal displacement as having preceded in time digital reduction, because I stated that one consequence of displacement had been the loss of the inner digit. This accusation is quite inexcusable, as I have never thought it necessary to express any opinion on the subject. Phenacodus (with which I am somewhat familiar) shows that reduction preceded displacement, to say nothing of Hyrax, cited by Osborn. Reduction followed disuse, and it is only the inner digit that has suffered finally through displacement.—E. D. COPE.

Note on the Pelvis of Cumnoria (Camptosaurus).—In a recent examination of Mr. Lydekker's admirable volume on vertebrate paleontology, I was struck with the conspicuous perpetuation of an

[3] On the Mechanical Origin of the Hard Parts of the Mammalia, 1889, p. 171.

error which should have been corrected before now. On page 1152, referring to the Ornithopoda he says: "The ilium generally has its preacetabular process much elongated, although this is not the case in the type of *Camptosaurus;*" and on page 1158, "The posterior portion of the ilium of this species [*Iguanodon fittoni*] is indeed almost indistinguishable from that of *Camptosaurus.*" If one will compare the figure of the pelvis of *Camptosaurus dispar* on page 1153 with that of *Iguanodon dawsoni* on page 1158, he will be struck with the strong resemblance throughout, except of the anterior portion of the ilium." The fact is that the figure of the former is wrong. The anterior portion of the ilium of the type had been broken off and weathered, indications of which are distinctly seen in the specimen. Prof. Marsh had this demonstrated to him more than five years ago, and there are other ilia in the Yale Museum in which this process is complete. It is to be hoped that this figure will be banished from text-books in the future, and that no new genus will be made on the supposition that the process is wanting.—S. W. WILLISTON.

BOTANY.

The Assimilation of Carbon by Green Plants from Certain Organic Compounds.—Under this title Mr. E. Hamilton Acton publishes in the Proceedings of the Royal Society (Vol. XLVII., p. 150) the results of an interesting series of experiments made by him to determine whether it can be produced in the assimilating cells of green plants when supplied with certain organic compounds, in the absence of carbon dioxide from the air. The following summary will give the essential parts of the paper.

The apparatus used consisted of a tall bell-jar, perforated at the top, and accurately ground at the bottom. Into the top an india-rubber stopper was accurately fitted, and through this were passed two bent glass tubes, each leading to a U tube filled with soda-lime. Inside of the bell-jar were placed a glass culture cylinder, a small dish of soda-lime, a couple of dishes of water, and a test-tube filled with a solution of caustic potash. The bell-jar was set upon a glass plate, and the contact was rendered air-tight by the use of a mixture of vaseline, resin and beeswax.

A normal "culture solution" was prepared with the following composition:

Potassium nitrate (KNO_3)	0.15 grams.
Magnesium chloride ($MgCl_2$)	0.10 "
Calcium phosphate ($Ca_3(PO_4)_2$)	0.05 "
Ferrous sulphate ($FeSO_4$)	0.025 "
Calcium sulphate ($CaSO_4$)	0.05 "
Water (distilled)	100. "

This was placed in the culture cylinder, and to this were added the organic compounds experimented with. The plants used were either cut branches, or plants with roots, and these were supported by a cork in the mouth of the culture cylinder, in the usual way. Applications of the organic compound were also made directly to the surfaces of the leaves of plants.

The plants used were first deprived of all their starch, either (a) by being placed in the dark for a sufficient length of time, or (b) by being placed under the bell-jar described above, where, having no access to carbon dioxide, the same result was obtained with greater convenience. After such preparation they were placed in the culture solution, to which an organic compound had been added. On exposure to light in some cases starch was formed, although all access of carbon dioxide was cut off, thus proving that the plants formed starch by conversion of the organic compounds. The results were as follows:

1. Neither acroleïn nor acroleïn ammonia (C_6H_9NO) were used by the plants. No starch whatever was formed.

2. With allyl alcohol (C_3H_6O) similar results were obtained.

3. With glucose (one per cent. solution) starch was produced in every instance.

4. With aldehyde no starch was formed.

5. With weak solution (0.05 to 10 per cent.) of pure glycerine starch was invariably formed.

6. With lævulinic acid no starch was formed.

7. With pure cane sugar starch was invariably formed.

8. With dextrine no starch was formed.

9. With inulin starch was formed.

10. With "soluble starch"[1] the cut branches formed starch, but those supplied with roots did not.

11. With glycogen no starch was formed.

[1] Soluble starch was prepared by rubbing wheat starch with cold water into a thin paste, and then pouring it into an excess of boiling water, and boiling for five minutes. On cooling, the solution was filtered through paper, and diluted to a strength of about one per cent.

12. With an extract of natural humus starch was formed in small quantities, in the case of rooted plants; in other cases no starch was was formed.

13. With the humus-like product obtained by the action of alkalies on cane sugar, no starch was formed.

The plants used were chiefly *Acer pseudoplatanus, Phaseolus vulgaris, Ranunculus acris, Cheiranthus cheiri, Tilia europœa, Alisma plantago, Scrophularia aquatica, Quercus robur, Campanula glomerata, Euphorbia helioscopia, Lilium candidum.*

The author concludes: "That green plants cannot normally obtain carbon for 'assimilation' from any substances except carbohydrates, or bodies closely related to them, not from aldehydes or their derivatives, and not from all carbohydrates even." "That a compound may be a source of carbon when supplied to the leaves, but not when supplied to the roots, and *vice versa.*"

The Yellow Water Crowfoot.—This common plant of the eastern half of the continent, known hitherto under the name of *Ranunculus multifidus* may have to bear the name of *Ranunculus lacustris*, given it by Beck and Tracy in the third edition of Eaton's Manual (1822). Professor Greene, in a recent number of *Pittonia*, points out the fact that this name appears to have priority. He also calls attention to the fact "that no one has yet stated whether *R. lacustris* be annual or perennial," saying farther that "probably nobody knows."

It probably lives for about a year. The seedlings appear late in the autumn along the banks, and on the bottoms of dried up pools, ready to make an early growth in the following Spring. I have never found any evidence of the full grown plants lasting through the winter. Possibly they may do so, in exceptionally mild winters, as is indeed the case with many other plants.—CHARLES E. BESSEY.

Atlas of French Plants.—Some months ago the first number of an important work by A. Masclef, was brought out by a Paris publishing house (Klincksieck,) under the title "Atlas des Plantes de France, utiles, nuisibles et ornamentales." When complete it will include two hundred colored plates, and about three hundred and fifty pages of text, at a cost of fifty francs. The pages and plates are of octavo size, and the latter are very well done. The work will prove a valuable one, especially to experiment station workers.

The Characeæ of Germany.—The fifth volume of the new edition of Rabenhorst's "Kryptogamen-Flora von Deutschland, Oesterreich und der Schweiz," is to be devoted to the Characeæ. The work

is in the hands of Dr. W. Migula, of Karlsruhe, and promises to be of great interest and value. Parts I. and II., which have appeared since the first of the present year, are largely devoted to a discussion of general matters. In part II. we have an outline of Dr. Migula's system of classification as applied to the Characeæ. He insists npon their isolated position in the vegetable kingdom, and proposes the name Charophyta for the group, which contains about one hundred and fifty species (and subspecies) in the whole world. These are distributed among six genera, which in turn fall into two sub-families.

CHAROPHYTA.

Family Characeæ.—1. Sub-Family Nitelleæ.—Gen., *Nitella* and *Tolypella*.

2 Sub-Family Chareæ.—Gen., *Tolypelopsis*, *Lamprothamnus*, *Lychnothamnus* and *Chara*.

The German species of *Nitella* number thirteen, nearly all of which are described by the end of Part III. lately received. Good illustrations accompany the full text, and thus give us a most usefu[1] work.

ZOOLOGY.

Hoplophoria coralligens.—Is a new Actinian from the Bahamas, described by Dr. H. V. Wilson.[1] Only a single specimen was found. In general structure it was on the ordinary Hexactinian type. The mesenterial filaments were typical, and there were no acontia. The specimen was a female, with ovaries developed on but four mesenteries belonging to the primary cycle. Just beneath the circle of tentacles are four large organs which are diverticula of the gastrovascular space, and which are stinging weapons. These structures are not modified tentacles, but are homologised with the marginal sacs (randäsckchen) which were formerly regarded as eyes in many Actinians. Hoplophoria is regarded as a member of the Antheadæ, in which, besides the points enumerated above, only the six primary mesenteries reach the œsophagus.

[1] Studies from the Biol. Lab., Johns Hopkins Univ., IV., p. 379, 1890.

Dinophilus.—S. F. Harmer describes the anatomy of *D. tæniatus*.[2] The animal has two circles of preoral cilia, while each of the five body segments bears two similar circles, interrupted by the uniform ciliation of the ventral surface. The large brain nearly fills the preoral lobe, while the œsophageal commissures connect it with the widely separated ventral cords. These latter lie just outside the basement membrane of the skin, and are provided with five ganglionic swellings. The paired eyes are on the top of the brain; each consists of a pigmented sac filled with a clear substance. Below them is a pair of small sacs opening to the mouth, and innervated from the œsophageal cords. The mouth is ventral; the oblique œsophagus receives the ducts of the salivary glands and terminates in the large stomach. This latter is prolong behind into a dorsal cæcum, while below it communicates with the intestine. The anus is just above the tail. The body cavity is but slightly developed. Five pairs of nephridia are present, the hinder pair being converted in the male into vesiculæ seminales. In the young the testes consist of a couple of ventral bands, but in the adult these are enlarged and united both anteriorly and posteriorly. The ovaries are four-lobed. A penis is present, and Harmer has witnessed copulation. Harmer agrees with most observers in regarding Dinophilus as one of the Archianellida. This species is about 2 mm. long, orange in color, and occurred in tide pools at Plymouth, England. Specimens were abundant April 18th. None could be found June 26th.

Note on an American Species of Phreoryctus.—The family Phreoryctidæ is composed, as heretofore known, of one genus, containing three species of long and slender oligochæte worms, two of which have been reported from the continent of Europe[3] and one from New Zealand.[4] In Germany, one of the species, *P. menkeanus*, has occurred quite frequently in the water of deep wells. In America this family seems to have escaped observation, as has been already remarked, in fact, by Dr. Minot, in his article on Vermes in the *Standard Natural History*. Recent observations here show, however, that the species is an inhabitant of the subterranean waters of this region; and I have been fortunate enough to obtain three examples from a farm drain, where the tile was stopped by an ingrowth of the roots of trees.

[2] Jour. Marine Biol. Assn., United Kingdom, No. 2., p. 119. 1889.

[3] See Vejdovsky, "System und Morphologie der Oligochaeten," pp. 48-50.

[4] "On the Reproductive Organs of Phreoryctus." By Frank E. Beddard, M.A., *Ann. Mag. Nat. Hist.*, Ser. 6, Vol. I., No. 6 (June, 1888), p. 389.

This new form is clearly a species undescribed, distinguishable at once from the others by the lack of dorsal setæ on all but the anterior segments of the body. The ventral setæ, on the other hand, are very large and stout, with strongly hooked tips,—diminishing in size near the two ends of the body.

The following description will serve to identify the species.

Phreoryctus emissarius, n. s.

A very long and slender worm, six to eight inches, or more, in length (in alcohol), by .6 to .7 mm. in diameter,—the segmentation very distinct, the color pale red, the cuticle highly iridescent. The cephalic lobe is separated from the first segment by a rather deep lateral constriction. It is broadly rounded in front, and about two-thirds as wide as long. I do not see the transverse division of this lobe remarked by Vejdovsky and Beddard in the other species. Segments nearly quadrate, four hundred or more in number. (An imperfect specimen contained three hundred and seventy-five.) Setæ single, acute, the first segment with two very small ventral and no dorsal ones. Four rows on the following segments to the eightieth or ninetieth; on the remainder of the body only two rows, the dorsal setæ disappearing. The last of this series become very minute and variable, and are frequently wanting on here and there a segment preceding the last that bears them. The ventral setæ are very large and long, and strongly hooked, but diminish in size at the two ends of the body. They project into the cœlom, when retracted, a distance equal to two-thirds the whole diameter of the worm.

Two longitudinal blood vessels, both closely applied to the alimentary canal, one dorsal and one ventral, the dorsal one contractile. A pair of long contorted vascular arches in each segment, extending loop-like into the ventral cœlom, below the sub-intestinal vessel. Nephridia, a pair to each segment, opening upon the surface a short distance *in front* of the ventral setæ.

Champaign, Ill., April 14, 1890. S. A. FORBES.

Sea-Urchin Excavations at Guaymas, Mexico.—Since the publication of my paper [NATURALIST, Jan., 1890] on sea-urchin excavations, I have received a letter from Prof. F. W. Cragin, of Washburn College, Topeka, Kansas, from which I make the following quotations:

"During a short stay at Guaymas, Mexico, in the winter of 1882–'3, I collected for Washburn College a considerable number of sea-urchins of two species, of which you afterwards sent me the names

[based on examination of examples of each which I submitted to you] which are *Echinometra vanbrunti* A. Ag., and *Cidaris thouarsii* Val. These were all collected on the sides of a great open sea-cave in the face of a beetling cliff in the outer portion of Guaymas Harbor, and were taken without exception, so far as I now remember, from holes in the solid rock. This was my first knowledge of the rock-boring habit of sea-urchins; but as I supposed the habit to be general with these species, and the matters of my observation to be well-known to all other naturalists, I did not venture to publish it. One fact which I observed, however, seems to me to be at variance with one of your conclusions. In collecting the urchins, I soon learned that if I wished to extract the specimens without injury to themselves, or, in case of the Echinometra, to avoid total failure, made more pointed by pricking my fingers, I must make up my mind in advance just how to seize them to best advantage and then to withdraw them quickly. If I was awkward or slow in any case, or hesitated and took a fresh hold from pricking my fingers, the Echinoderms took occasion to "set" a multitude of spines against the walls of their "geode," and, thus braced, could usually defy further efforts to remove them, save by such harsh means as fractured the bodies of the animals. I am therefore constrained to believe that on being disturbed by the violence of tide and storm-waves, to which they are here greatly exposed, they would set the spines, as they do in a case of human interference. It would certainly then be a rare thing that the action of the water should move them, though it is obvious that if it did succeed in moving one or more of its spines a little, the mutual erosion of spine and rock would be greater than if the spines were not braced. It seems to me, therefore, that very little erosion, so far as the action of the spines is concerned, would be caused by the sea-urchin washing about in the geode, but that the wear produced by the spines, and on the spines themselves, would be due to what might be called the *walking* of the spines; that is, the removing of a spine here and there from its position to such new positions as circumstances demanded. That certain of the spines are so used and become somewhat worn in the case of the two species above mentioned, is possibly indicated by the fact that some of them are obliquely truncated; yet the truncated end seems to be hardly smooth enough for a worn surface, and is perhaps a surface of fracture. Many of the spines have the tip perfect, but it is noticeable that in the Cidaris, whose spines are usually incrusted with species of Serpula and Spirorbis, the tip of the spine is bare or nearly so, and in some instances appears to have been worn bare. The rock in which the excavations were made

was very hard, igneous or metamorphic, I think, though I took no note of its lithologic character."

The above quotation is interesting as giving a new location for sea-urchin excavations, although A. Agassiz has already mentioned the rock excavations made by the same species at Panama.

Sea-urchin excavations near San Diego, California, have also been called to my attention by Dr. Cleveland and Mrs. R. S. Eigenmann, and an account of the same from near the Santa Barbara Islands was given me by a fisherman.

A. Agassiz says: "On the coast of California the common *Strongylocentrotus purpuratus* occurs in the same way [as in the Azores,—'in cavities dug out of the solid rock,]; we find long tracts of the shore, where this sea-urchin is common, completely honey-combed and pitted by cavities and depressions, in which they seek shelter against the powerful surf continually beating against the rocks. The same species does not excavate in sheltered places, where sea-urchins can find protection between the interstices of large fragments of rocks, or ledges more or less sheltered from the direct action of the open sea." [Revision of the Echini, p. 706.] It would seem that these excavations are not uncommon to the west coast of North America, although very few definite localities where they occur have up to the present time been recorded.

As the author desires to gather information in regard to the distribution of sea-urchin excavations, and the extension or limitation of the habit among genera and species of the Echinoidea, he desires to correspond with any who may have observed this phenomenon on any coast. He wishes especially information as to the names of the species of sea-urchins which make the excavation, the kind of rock excavated, and peculiar circumstance connected with the species.

Boston, Mass., April 9th, 1890. J. WALTER FEWKES.

The Ribs of Vertebrates.—At the last meeting of the Anatomical Society, at Berlin, Professor Hatschek presented some new evidence as to the homologies of the ribs within the vertebrate phylum. In Polypterus there are certain peculiarities which have been given different interpretations by different observers. In the body region each vertebra bears a pair of processes which extend from the centrum in a transverse direction, and are continued by a rodlike bone of considerable size. Just below this is a second delicate bony thread. In the caudal region the processes and their continuation diminish, while the ventral thread becomes larger and forms the hæmal arch.

According to some the ventral bones are homologous with the ribs of other fishes, while the dorsal rods are "flesh bones." According to others exactly the reverse is true. As tests, Hatschek calls attention to the fact that the muscles in the body of a vertebrate are divided into dorsal (epiaxial) and ventral (hypaxial) portions. In the fishes the ribs occur between the hypaxial portions and the somatopleur, while the ribs of Batrachia and Amniotes are new structures lying between the epi- and hypaxial portions. In the body regions of these forms the old fish ribs have disappeared, although they occasionally reappear in the caudal portion, old and new ribs coexisting together. Applying this test of position to the structures seen in Polypterus it is seen that the first view is the correct one, the dorsal half being the new or Batrachian rib. In Batrachia and Amniotes the rib articulates with the vertebral centrum by two articular processes which primitively represent a forked proximal extremity. Götte found that the rib in its development consisted of dorsal and ventral portions, which distally grow together while proximally they remain forked. Wiedersheim compared only the lower portion with the ganoid rib, and regarded the dorsal portion as a new structure. This seems to be negatived by the conditions found in the Batrachian tail. Hatschek farther concludes that the vertebrate skeleton should be divided into somatic and visceral portions, and that the former should be further subdivided into axial, dermal, and septal portions, the latter embracing the portions arising in the myosepta.

The Families of Ribbon-fishes.—In the AMERICAN NATURALIST for January, 1887 (Vol. XXI., p. 86), I have given a diagnosis of the Tæniosomi. We have now the data for determining the common and comparative characters of the best known and only certain representatives of the suborder. For the Regalecidæ Prof. Parker's valuable Memoir (T. Z. S., Vol. XII., pt. 1), and for the Trachypteridæ, a lately published monograph by Alexander Week (Studies Mus. Zool., Univ. Dundee, Vol. I., pt. 6), furnish the requisite information. The differences between the two families are greater than would have been anticipated, and necessitate a revision of the diagnosis of the suborder. The characteristics may now be expressed in the following terms:

TÆNIOSOMI.

Teleocephals with the scapular arch subnormal, posttemporal undivided and closely applied to the back of the cranium, between the epiotic and pterotic, or upon the parietal; hypercoracoid perforate at

or near the margin; cranium with the epiotics enlarged, encroaching backward and juxtaposed behind, intervening between the exoccipitals and supraoccipatal; prootic and opisthotic represented chiefly by the enlarged prootic; the suborbital chain imperfect; the copular bones separated by intervening cartilaginous elements; the hypopharyngeals styliform and parallel with the branchial arches, epipharyngeals in full number (4 pairs), and mostly compressed; the dorsal fin composed of inarticulate rays or spines, separable into lateral halves, and the ventrals (when present) sub-brachial.

A myodome may be present or absent, none being developed in the Regalecidæ, but one being distinct and supplemented by a dichost in the Trachypteridæ. The families may be briefly differentiated as follows:

TRACHYPTERIDÆ.

Tæniosomes with the body moderately elongated and very compressed, the head short, the opercular apparatus abbreviated (the operculum extended downwards, the suboperculum below it, and the interoperculum contracted backwards and bounded behind by the operculum and suboperculum), ventrals pauciradiate in young, atrophied or lost in adult, the cranium with a myodome and dichost, the supraoccipital continued behind into a prominence, the epiotics confined to the sides and back of the cranium, and without ribs.

REGALECIDÆ.

Tæniosomes with the body very elongated and compressed, the head oblong, the opercular apparatus well developed (the operculum extended backwards, the suboperculum obliquely behind it, and the interoperculum extended upwards below the two), the preorbital chain oblique and widest at the second bones, ventrals represented by single elongate rays, the cranium with the myodome atrophied, and the dichost suppressed, the supraoccipital pushed forward by the extensive development of the epiotics which encroach forwards on the roof as well as back and sides of the cranium, and with short ribs.—THEO. N. GILL.

The Genera of the Podocnemididæ.—Through the kindness of Prof. R. Hertwig, of Munich, I have received the skull and cervicals of two specimens of the type of *Emys tracaxa* Spix. for examination. I am now able to give the characters of the known genera of the Podocnemididæ. Boulenger considers *Emys tracaxa* Spix. the type of *Peltocephalus* Dum. & Bibr., and *Dumerilia madagascar-*

iensis Grandid., the type of my Erymnochelys, generically the same as Podocnemis.

The genus Dumerilia was established by Grandidier, but since this name had been used different times before, I introduced the name Erymnochelys (*Zool. Anz.*, No. 285, 1888.) After this, Boulenger claimed that Erymnochelys mihi (Dumerilia, Grandid.) was a synonym of Podocnemis. In No. 296 of the *Zool. Anz.*, 1888, I gave the generic characters which distinguish Erymnochelys from Podocnemis. I said in Erymnochelys the jugal is in extensive connection with the quadrate; this connection is absent in Podocnemis; in Erymnochelys the prefrontals are produced in front and without median groove; the cervical vertebræ form single condyles. In Podocnemis saddle-shaped vertebræ, as in birds, are present.

In the general shape of the skull Peltocephalus resembles Macrochelys; Peltocephalus is in the same relation to Erymnochelys, as Macrochelys to Chelydra. Morphologically the skulls of Erymnochelys and Peltocephalus are very much alike; but Peltocephalus has the saddle-shaped cervicals of Podocnemis.

The atlas of Podocnemis is entirely different from that of Peltocephalus and Erymnochelys. In Podocnemis the first intercentrum is small and free. In Erymnochelys and Peltocephalus it is large and internally united with the neuroids and the centrum of the atlas.

I give now a table of the characters of the three genera:

Podocnemis, Wagler.

Jugal and quadrate bones separated; articular faces of anterior cervicals saddle-shaped; first intercentrum small and free. Type: *P. expansa*, Schweigg.

Peltocephalus, Dum. and Bib.

Jugal and quadrate in contact; articular faces of anterior cervical saddle-shaped; first intercentrum large and suturally united with neuroids and centrum of atlas. Interparietal shield triangular with base behind. Type: *P. tracaxa*, Spix.

Erymnochelys, Baur.

Jugal and quadrate in contact; articular faces of cervicals not saddle-shaped; first intercentrum large and suturally united with neuroids and centrum of atlas. Interparietal shield triangular with base in front. Tpye: *E. madagascariensis*, Grand.

Note.—The condition of the atlas in Peltocephalus and Erymnochelys, must be considered as one from which the condition seen in the

Pelomedusidæ has been derived. In the Sternothæridæ (Pelomedusa, Sternothærus) there is no trace of a suture between intercentrum and the centrum of the atlas. If the sutures of the atlas in Peltocephalus or Erymnochelys would disappear, we would have the conditions of the Sternothæridæ. Erymnochelys and Peltocephalus agree with all known Pleurodira in the fact that the centrum of the atlas supports the neuroids; a condition never seen in the Cryptodira or Chilotæ (Tronychia). (Baur, *Ann. and Mag. Nat. Hist.*, July, 1889).—G. BAUR, PH.D.

Note on the Genera Hydraspis and Rhinemys.—Boulenger accepts in his catalogue of Tortoises the genera Hydraspis and Rhinemys. His genus Hydraspis contains seven species, *H. hilarii, H. tuberosa, H. geoffroyana, H. gibba, H. radiolata, H. rufipes, H. wagleri.*

His genus Rhinemys contains one species, *Rh. nasuta.*

Rhinemys is characterized: Neural plates present; parietal bones not expanded superiorly; parieto-squamosal arch very slender.

Hydraspis: Neural plates present; parietal bones expanded superiorly; parieto-squamosal arch strong.

The question is; first, can the name Hydraspis be adopted; aud second, is Hydraspis generically different from Rhinemys, Boulenger, non Wagl.

1. *Can the name Hydraspis be adopted?*

In 1811 Oppel[1] separated *Emys longicollis* from Emys as a "subgenus," for which he gave the following diagnosis; Collo longissimo, subtestam arcuate reflexo, non retractili; *e.g., E longicollis*, without creating a new name.

In 1828 Fitzinger[2] established Chelodina for "Emys longicollis und consorten." The type of Chelodina is therefore *Emys longicollis* Shaw.

Two years latter Bell[3] established the genus Hydraspis, with nine species (p. 512), *Testudo longicollis*, which I consider the type; *T galeata* of Schoepff, *T. planiceps* Schoepff, *Emys amazonica, E. viridis, E. depressa, E. macrocephala, E. tracaxa, E. rufipes* Spix.

Later on (p. 515) we find Hydraspis: sp. typ. *H. galeata* (*Testudo galeata* Auct.) It is quite evident that Bell's Hydraspis is simply a synonym of Fitzinger's Chelodina, and has no right to existence.

[1] Oppel, Michael, Die Ordnungen, Familien und Gattungen der Reptilien. München, 1811, p. 12.

[2] Fitzinger, L. J. Neue Klassification der Reptilien, Wien, 1826.

[3] *Zool. Journ.*, III., 1828.

In 1830 Wagler establishes the genera: Rhinemys, Hydromedusa, Podocnemis, Platemys, Phrynops, Pelomedusa.

Rhinemys contains the species: *Emys rufipes*, Spix., *Emys nasuta*, Schweigg, *Emys radiolata*, Spix., *Emys gibba*, Schweigg. The type of Rhinemys is *Emys geoffroyana* Schweigg. It is now proper to examine whether *Emys rufipes* Spix., is generically different from *Emys geoffroyana* Schweigg; in other words, whether Phrynops is different from Rhinemys. Through the great kindness of Prof. R. Hertwig, of Munich, I have received the skull of the type of *Emys rufipes* Spix. for examination. The skull is characterized by the very much expanded parietals, which are twice as broad as the interorbital space.

In *Emys geoffroyana* Schweigg, the type of Phrynops, the parietals are not so much expanded, but in all other respects Phrynops agrees with Rhinemys, and there can be no doubt that Phrynops is not different generically from Rhinemys.

The type of Rhinemys Wagler is *Rhinemys rufipes* Spix; the other species of Rhinemys are: *Rh. hilarii*, *Rh. tuberosa*, *Rh. geoffroyana*, *Rh. gibba*, *Rh. radiolata*, *Rh. wagleri*. Boulenger's Hydraspis is therefore synonym of Rhinemys.

2. *Is Boulenger's Rhinemys generically different from his Hydraspis?*

In Rhinemys of Boulenger, with the single species *Rh. nasuta*, the parietals have become very slender; in other words the reduction, which has already begun in some of the species of Rhinemys mihi (Hydraspis, Blgr.) has increased. This, and also the slenderness of the parieto-squamosal arch, is certainly no reason to distinguish this form as generically different from the others. According to Boulenger there are only four neural plates in his Rhinemys, six in his Hydraspis, but the question is, whether the number is constant in Hydraspis; the number in *Rhinemys rufipes* and *Rh. wagleri* is not yet known. Of course there is no doubt that if Boulenger's Rhinemys should even prove to be different generically from his Hydraspis, the name Rhinemys could not be used, and another name must be given. I think it best to consider *Emys nasuta* of Schweigg as a species of the genus Rhinemys Wagler, as adjusted by me.

I give now the following synomy:

CHELODINA Fitz., 1826=Hydraspis Bell, 1828.
Type *Ch. longicollis* Shaw.

RHINEMYS Wagler, 1830=Phrynops Wagler, 1830=Hydraspis (Blgr.)+Rhinemys (Blgr.), 1889.
Type, *Rh. rufipes*, Spix.

—G. BAUR, Ph.D.

The Genera of the Cheloniidæ.—Boulenger, in his Catalogue of Tortoises, admits only two genera of Cheloniidæ—Chelone and Thalassochelys. His genus Chelone includes Caretta or Eretmochelys, Euchelys and Onychochelys. His Thalassochelys includes Lepidochelys, Colpochelys, Cephalochelys and Eremonia.

I have examined a great number of skulls and skeletons of Cheloniidæ in different museums, and have reached the following conclusions, which partially at least have been published before:

1. Chelonia Brogn., 1799. *Jour. des Sciences des Lettres et des Arts*, par A. L. Millin. Vol. V., 6, 1799.

Orbit formed by: prefrontal, frontal, postfronto-orbital, jugal, maxillary.

Maxillaries separated by vomer.

Descending processes of prefrontals in connection with palatines.

Number of peripheralia, 11; No. 10 without connection with rib.

Type: *Chelonia mydas* L.

2. Caretta Ritgen, 1828. Eretmochelys, Fitz.

Orbit formed by: prefrontal, frontal, postfronto-orbital, jugal, maxillary.

Maxillaries separated by vomer.

Descending processes of prefrontals without connection with palatines.

Number of peripheralia, 11; peripherale 9 without connection with rib.

Type: *Caretta imbricata* L.

3. Thalassochelys, Fitzinger, 1835.

Orbit formed by: prefrontal, postfronto-orbital, jugal, maxillary.

Maxillaries in contact, not separated by vomer.

Descending processes of prefrontals in connection with palatines.

Number of peripheralia, 11; peripherale 9 without connection with rib.

Type: *Th. caretta* L.

4. Lepidochelys (Fitzinger) Gray, Colpochelys Garman.

Orbit formed by: prefrontal, postfronto-orbital, jugal, maxillary.

Maxillaries separated by vomer.

Descending processes of prefrontals without connection with palatines.

Number of peripherlia, 11 or more; connection with ribs as in Thalassochelys.

Type: *L. olivacea* Eschsch.

Through the kindness of Dr. O. Boettger I have received a skull of *Lepidochelys olivacea*, from West Africa, for examination. Later I found in the collection of the Smithsonian Institution a skull of a sea-tortoise from Ventosa Bay, Mex., collected by Prof. Sumichrast, of the same genus.

Lepidochelys olivacea Eschsch. is distinguished from *Lepidochelys* (Colpochelys) *kempii* Garman, by the very much more expanded pterygoids, and the large ectopterygoid processes. There are no ridges on the alveolar surfaces of the upper jaw, and there is an indication of a median keel at the symphysis of the lower jaw.

The specimens on which the genera Euchelys, Girard, and Onychochelys, Gray, have been established I do not know, neither do I know Gray's genera, Cephalochelys and Eremonia. *Chelonia depressa* Garman, which is considered by Boulenger as a synonym of *Chelonia mydas*, without indication of any reason whatever, a thing very often repeated by Mr. Boulenger, does not belong to the genus Chelonia at all. Through the kindness of Mr. Garman, I have examined the type, which is represented by a stuffed specimen. The lower jaw has a greatly developed hook very much like *Lepidochelys kempii* Garman, but there is a median ridge on the symphysis, something like *Lepidochelys olivacea* Eschsch. Until the skull of this species is known, it is impossible to decide whether it belongs to Thalassochelys, Lepidochelys, or, what I think probable, to a new genus.

Chelonia multiscutata Kuhl is possibly an abnormal specimen of *Lepidochelys olivacea* Eschsch. Kuhl described this species after a specimen in Groningen. According to a letter kindly received from Prof. Van Anhum (dated Nov. 21, 1887), none of the collections at Groningen contain the original.

There is a great number of species of Cheloniidæ, which have been described by different authors; future examinations will show whether these species are in existence or not. There is no doubt whatever that the Chelonia from the Pacific is a different species from the Atlantic; the skulls are the same, but there are great differences in the form of the carapace. I have seen a great number of young specimens of Chelonia collected by the Albatross on the Galapagos Islands. These have 1–6 peculiar dermal plates between the marginalia and the infra-marginalia. I propose to call these plates *submarginals*. It remains to be decided whether this species is the same as *Chelonia agassizii* Boc., or not.—G. Baur, Ph.D.

Zoological News.—Molluscs.—Garstang, in a catalogue of the Nudibranchs of Plymouth, England,[1] gives many instances of the protective coloration of these forms. The author catalogues thirty-six species, the whole making with the notes an admirable faunal list.

J. I. Peck describes[2] the anatomy and histology of the Pteropod *Cymbuliopsis calceola*. The muscles, digestive organs, nervous system, reproductive organs, nephridium, and heart were investigated. The nephridium does not communicate with the pericardium. In the individual studied no penis was found, although the gonad was in female cativity, and the receptaculum was full of spermatozoa.

Arthropods.—W. F. R. Wheldon thinks[3] that the tendency of zoeæ to develop their protective spines in one straight line, parallel with the long axis of the body, is of no little advantage in aiding the embryo to swim in a straight line, like men sculling in a narrow racing boat.

G. C. Browne catalogues[4] sixteen species of Copepoda, collected at Plymouth in 1888–89. The notes are largely synomymical.

Some interesting notes the on habits of Crustacea[5] are worthy of notice. Shrimps and prawns keep buried by day, and wander about by night; even those with the eyes extirpated show the same features. Crustacea find their food almost exclusively by scent, while it seems probable that they cannot see much, possibly not even each other. To light and shade, however, they are very sensitive. Certain crabs are fond of decorating themselves with seaweed, etc. The crab takes a bit of weed in its chelæ and deliberately tears it across. He then puts one end into his mouth, and after chewing it up, presumably to soften it, takes it out in his chelæ and rubs it firmly on his head or his legs until it is caught by the peculiar curved hairs which cover them. If not caught it is chewed again, and the process repeated. This is done by night as well as by day, and specimens deprived of sight will clothe themselves as do the others. It is noticeable that there is a marked bilaterality in the arrangement of this ornamention. It does not appear that it is for concealment.

[1] *Jour. Marine Biol. Assn.*, No. 2, p. 173, 1889.

[2] *Studies Biol. Lab.*, Johns Hopkins Univ., IV., p. 335, 1890.

[3] *Jour. Marine Biol. Assn.*, No. 2, p. 169, 1889.

[4] Ibid., p. 144, 1889.

[5] Ibid., p. 211.

EMBRYOLOGY.

The Continuity of the Primary Matrix of the Scales and the Actinotrichia of Teleosts.—In *Batrachus tau*, if transverse sections are prepared from embryos a few days after hatching, it will be found that a basement membrane underlies the whole of the epidermis, as an extremely thin layer. This layer of homogeneous matter covers the entire larval fish, and is interposed between the organs of mesoblastic origin and epiblast everywhere. In the fin folds there are linear and parallel thickenings of this thin lamina of basement membrane which eventually become the actinotrichia, as I have named the primary fibrous rays of all fishes. The mesoblastic cells which aid in developing the actinotrichia have a disposition to lengthen in a direction parallel to the latter.

The membrane over the rest of the body is continuous in Batrachus, and doubtless represents the matrix of scales in other forms. Its continuity shows that the matrix of scales was probably originally continuous in all fishes, and that the lateral bendings of the body in locomotion have been in part the efficient cause of the segmentation of the continuous layer, into, at first, oblique bands as in Callichthys, and then into lozenge-shaped tesseræ. These bands doubtless conformed in direction at first, in some cases, to the underlying muscle plates Later secondary modifications introduced other complications.

This evidence is at any rate highly interesting as pointing to the conclusion that the primary basis of the exoskeleton of fishes is conclusious, so as to form an unbroken cuticular investment of the entire mesoblast.

It also affords striking confirmation of my hypothesis[1] that the exoskeleton is to be traced phylogenetically to an uninterrupted cuticular or basement membrane occupying the position of the mesoglœa in cœlenterates such as the Medusae and Hydroids.

Aggregations of this cuticular membrane constitute the basis of the "cementum plates" of the teeth of fishes. The ganoin and variously modified enamel of ganoid scales is a derivative of the epidermis proper. The cementum plates grade very gradually into the various types of osteodentine, and into that form of dentine with ramifying tubules seen in some ganoids and known as cosmin. Such aggregations or local thickenings of the cementum have arisen in the first place as the con

[1] A physiological theory of the calcification of the skeleton. Proc. Am. Philos. Soc., Vol. XXVI, 1889.

sequence of the local aggregation in groups, due to local stimulation, of the underlying connective tissue cells.

The Teleosts accordingly still bear traces of having a great capacity for developing the matrix of a protective dermal skeleton ; far greater than in other types. In birds, mammals, reptiles, and batrachia, of a corresponding larval stage of development, the continuous cuticular or basement membrane beneath the epidermis, is either entirel · wanting, or is never developed except locally at relatively much later stages.

There is also evidence to show that with the progress of evolution this primary superficial matrix has tended to be carried inward toward the cartilage so as to form the membrane bones, particularly on the head. Yet there are other regions where an engulfing of the superficial subepidermal calcifications in membrane occurs during the life of the individual. In the common sturgeon the preanal scales or scutes are superficial and exposed, except for their very thin covering of epidermis ; in the adult, on the contrary, these scales are so deeply embedded in the tissues as to be completely lost to sight externally, and lie so far below the epidermis as to be exposed only by recourse to the scalpe It is this peculiar circumstance that has given rise to the erroneous belief amongst ichthyologists that some of the abdominal scales of the sturgeons were "deciduous."

The continuous investment of the mesoblastic tissue of the larvæ of recent scaleless Teleosts, such as Batrachus, by a structureless basement membrane which can be identified with a true scale matrix shows how persistently the armature of the Devonian types still tends to be inherited, even by a form not developing true scales. It is probably a good illustration of what Eimer means by his theory of "constitutional impregnation," or, as one might say, saturation with inherited tendencies.

With the advent of the body-cavity, gut-pouches, and mesoblast of triploblastic types, the mesoglœa of the diploblastic type would be divided, that is to say, some of the matrix would be deposited upon the functionally inactive (in digestion) derivatives of the intestine, such as the notochord, while some would be deposited by the same secretory activity of the mesoblast upon the inside of the epidermis. This division, determined by purely physiological agencies, therefore gives both the matrix of the endoskeleton and that of the exoskeleton. The active translation of new matters, or metabolism, through the intestinal walls prevents the deposit of any cuticular membrane there, and it is only over the ametabolic notochord, which is an indirect derivative of the intestine, that such a deposit can take place.

The actinotrichia are at first joined together by a thin cuticular membrane; later, they separate more widely, and the intervening membrane between the actinotrichial fibres disappears. The latter also are not round at first, but flattened, or oval in cross-section. Their greatest diameter also corresponds to the direction of the plane of the membrane of which they form a part.

To the proximal ends of the two rows of actinotrichia the fin muscles were originally attached, as may still be seen in sharks, Dipnoans and Chimæroids. This insertion of the fin muscles, their serial action from before backward, as well as the necessary undulatory motion of the tail from before backward in the act of locomotion, must throw the fin folds into a lateral undulatory motion from before backward. This undulatory motion would tend to favor the breaking of the cuticular membrane under the epidermis of both sides of the fin into parallel threads, owing to the short flexures into which its substance must be thrown. In this way the genesis of the actinotrichia themselves may be traced to the direct action of physical causes. The subsequent cross-fracturing of the rays derived from a further development of the actinotrichia, I have elsewhere proved to be due to the interaction of the organism and the resistance offered by the surroundings to the motions of the fins.[1]

The thickness of the continuous subepidermal basement membrane in Batrachus, also varies in a singular and suggestive way. It is decidedly thicker on the dorsal aspect and on the upper portions of the sides of the body, and thinnest on the ventral aspect which is most protected in this form, which, as is well known, lives by preference at the sea-bottom resting on the mud.

In the earlier forms of fishes, such as Coccosteus, Mycterops, Pteraspis, Cephalaspis, etc., there was a tendency to form an unbroken dorsal cephalic shield. This tendency is still preserved in the evolution of the cranial plates of the sturgeon on the sides and top of the head, and is expressed on the body, in that the dorsal scutes are always the first to be developed. The development of the cranial exoskeleton in primitive forms, and in now existing types representing the latter, therefore coincides with this early appearance of traces of the superficial skeletal matrix in a subepidermal position on the dorsal aspect of the head and body in the existing larvæ of unarmored forms, which may be supposed to have lost such a defensive exoskeleton. The parallelism here pointed out is, at any rate, extremely suggestive, and if capable of further demonstration will show how persistently an extremely ancient character tends to be inherited. JOHN A. RYDER.

[1] Proofs of the effects of Habitual use in the Modification of Animal Organisms. Proc. Amer. Philos. Soc. Vol., XXVI., 1889.

MICROSCOPY.

Professor Butschli's Experimental Imitation of Protoplasmic Movement.[1]—Professor Bütschli, of Heidelberg, has recently made some extremely interesting observations upon a substance which simulates in a remarkable way the appearance and movements of protoplasm of an Amoeba, or of the plasmodium of Mycotozoa. He has been kind enough to send to me some oil in a suitable condition for use, with directions as to the exact details of the experiment. In my laboratory, by following his directions, the movements described by him have been observed in a satisfactory manner. In order to obtain the best results some experience and care is requisite, and probably cannot always be obtained by a single experiment. The subject is so interesting, and so fitted for further investigation by all who have leisure and taste for the study of the vital phenomena of the Protozoa, and of living protoplasm in general, that I think it will be of advantage to the readers of this journal to have Professor Bütschli's directions, which he has permitted me to publish, placed in their hands.—E. RAY LANKESTER.

March, 1890.

HEIDELBERG, February 1st, 1890.

You have kindly asked me how I prepared the protoplasma-like drops which I have described. As you yourself feel greatly interested in this discovery, and presumably a like interest exists among other English biologists and microscopists, I hasten to satisfy your desire, and to explain somewhat more fully the methods which I have described in a previous publication.

As you well know already, I use in the preparation of these globules, —showing protoplasma-like streaming,—ordinary olive oil. My first experiments were made with a small quantity of olive oil, which had been standing for a long time in my laboratory in a small bottle. By some happy chance this oil had just the right properties which are necessary for the success of the experiment, for not every sort of oil is suitable. As far as my experience goes it tends to show that the ordinary oil cannot be directly used, because it is too thin, or is perhaps deficient in other qualities on which the success of the experiment depends. In order, therefore, to prepare a suitable oil, I proceed in the following manner: A medium-sized watch-glass, or flat dish, is

[1] From the *Quarterly Journal of Microscopical Science*, Vol. XXXI. April, 1890.

filled with a thin layer of common olive oil, and is placed on a water-bath or in a small cupboard, such as are used for imbedding in paraffine, at a temperature of about 50° C. Under the influence of the higher temperature the oil gradually loses its yellow color and becomes thicker. The great point now is to select the right moment at which the oil will have attained the proper degree of thickness and viscosity, as also the other properties, which at present I am not able to define more exactly, but on which much of the success seems to depend. The exact moment can, however, only be found out by systematic trials. After the oil has been thickening for three or four days, a tria should be made with a drop of it in the manner described below Should the drop not become finely vesiculate, and exhibit little or no streaming, continue the heating process, and experiment again on the following day. If the oil should become too thick it will form good, frothy drops, but will scarcely show any streaming. In this case mix it with a small quantity of ordinary olive oil, and thus render it more liquid. If it has become much too thick it will form a good froth, but the latter dissolves very rapidly in glycerine.

You see that the process to obtain the suitable oil is somewhat slow but I do not at present know of any other method by which the resule can be reached more quickly and surely.

To prepare the vesiculate drops I proceed in the following way: — In a small agate mortar I grind a small quantity of pure dry carbonate of potash (K_2CO_3) to a fine powder. I then breath on the salt till it becomes slightly moist, and with a glass rod add to it a drop of oil, mixing the two constituents to a thickish paste. The success of the experiment depends, however, more upon the nature of the oil than upon the proportion of the oil and salt in this mixture. Then, with a glass rod or a needle, I place a few drops of the paste, about the size of a pin's head or smaller, on a cover glass, the corners of which are supported by small pegs of soft paraffine. I then place on a slide a drop of water, and put the cover-glass over this in such a manner that the drops of paste are immersed in the water, but are not much compressed, to which end the corners of the cover-glass have been supported by the paraffine. The preparation is then placed in a deep chamber, and remains there about twenty-four hours. The preparation is then washed out with water by applying blotting-paper to one edge of the cover-glass, and supplying water at the other edge from a capillary tube.

If the drops have turned out well, they will begin almost immediately after this to move about rapidly, and change their shape continuously. The water under the cover-glass must now be displaced by glycerine,

diluted with an equal bulk of water, and the drops will then exhibit a vigorous streaming and forward movement, becoming gradually transparent. The amœboid movements are generally more distinct if the drops are somewhat compressed. If the drops do not show the streaming movement you may succeed in producing it by tapping the cover-glass slightly, by applying gentle pressure, or sometimes by breaking up the drops. For it seems as if at times incrustations were formed on the surface of the drops which prevent or impede the streaming movement, and which can, in part at least, be removed by the above-mentioned manipulations.

It is especially interesting to see how fast and beautifully the drops creep to and fro in water, or in half-diluted glycerine, even when they are not compressed. The streaming movement, on the other hand, is better seen if the drops are compressed, which may be done by inserting under the cover-glass a piece of broken cover-glass of medium thickness, and then removing the paraffine pegs. Then draw away the liquid until the necessary pressure is obtained. This streaming movement is better demonstrated twenty-four hours after the addition of the glycerine, as the drops will then be thoroughly cleared and transparent. Further, it is interesting to note that a progression of the drops takes place in the direction in which the streaming moves.

As this forward movement is rather slow in compressed drops, it is necessary to use a micrometer ocular to satisfy one's self of the advance.

Unfortunately the oils which I have prepared since my first experiments do not move and stream so well or so rapidly as those I employed then. The movement and streaming show themselves much more markedly and distinctly if they are examined on a warmed stage at a temperature of 50° C. If you should be in a position at your demonstrations to conduct the experiment at this temperature, the phenomena will certainly be much more evident.

From the preceding description you will see that it will be necessary, to obtain good results, to gradually get hold of the methods, and you must not doubt the correctness of the phenomena which I have described if the first trials do not give the desired results.

At all events, you will have at first to make some experiments so as to obtain an insight into the conditions and sort of phenomena, but I do not doubt that you will succeed in observing the appearances and in demonstrating them to others, though perhaps in not so vigorous a degree as I might desire.

I have lately made some other trials to render olive oil suitable for these experiments by heating it more rapidly. Although at present I

have no entirely reliable results, it seems to me that by heating ordinary olive oil to 80°—90° C. for twelve or twenty-four hours, a suitable medium may be obtained.

Finally, I would like to remark that I am the last person to defend the view that these drops, exhibiting protoplasma-like movements, are directly comparable to protoplasm. Composed as they are of oil, their substance is entirely different from protoplasm. They may be, however, compared with the latter, in my opinion, firstly with regard to their structure, and secondly with regard to their movements. But as the latter depend on the former, we may assume that the amœboid movement of protoplasm itself depends on a corresponding physical constitution.

These drops, too, resemble organisms inasmuch as they continue for days to exhibit movements, due to internal causes, which depend on their chemical and physical structure. I do not believe that up to this time any substance has been artificially prepared which, in these two points, viz., structure and movement, has so much resemblance to the most simple forms of life as have these reticulated drops. I hope, therefore, that my discovery will be a first step towards approaching the problem of life from the chemico-physical side, and towards passing from vague and general hypotheses of molecular constitution to the surer ground of concrete conceptions of a chemical and physical nature.

It is, however, a special satisfaction to me to hear that in your country, which has given rise to so many and so celebrated men in biological science, my investigations are followed with interest and sympathy.

With friendly greetings, I am yours sincerely,

O. Bütschli.

ARCHÆOLOGY AND ETHNOLOGY.

The Use of the Phonograph in the Study of the Languages of the American Indians.—At the meeting of the American Folk-Lore Society in Boston, on April 19th, Dr. J. Walter Fewkes read a paper on experiments which he had lately made with the phonograph in recording the songs, legends, and folk-lore of the Passamaquoddy Indians.

The necessity for some means of accurately recording and preserving the languages of the Indians has lately been met by the invention of the phonograph. This instrument has now been brought to such a

stage of perfection that it can be profitably used for that purpose. Hitherto a source of error in recording aboriginal folk-tales has been the liability of the translator to incorporate his own interpretations with those embodied in the stories as heard by him, and, as a result, erroneous interpretations have been introduced which it is difficult to eradicate. In order that folk-lore, as far as applicable to aboriginal races, may be placed on a scientific basis, an accurate record of the story as told by the reciter is necessary. This can be accomplished by the use of the phonograph, and the records thus made can be indefinately preserved.

The essayist visited, for the purposes of study, a remnant of the Passamaquoddy Indians near Calais, Maine, and obtained from some of the older men many fragments of legends, stories, ancient songs, country out rhymes and conversations. He also obtained from the lips of Noel Josephs, who sang it when the ceremony was last performed, an old song used in the "Snake Dance." The words of this song are archaic and the music is said to be very ancient. He also took records of war songs, a curious "trade song," and the song sung by the chief on the evening of the first day of the celebration of his election. These songs have been set to music from the records taken on the wax cylinders of the phonograph, and the words have been written out by the same means. In several of the legends obtained by the use of the phonograph, songs occur which are said by all the Indians to be very ancient. Forty cylinders were filled with these records, some of which are stories yet unpublished.

The results of this experiment have, it is claimed, shown that the phonograph is an important help to the student of Indian folk-lore, not only in preserving the tales, but also in an accurate study of the composition of the music and the language.

To indicate its value, the spelling of the words, as spoken by the machine is found, to convey, as nearly as possible by phonetic methods, the pronunciation of the Indian words.

These studies of the Passamaquoddy language were undertaken as a preliminary to å visit to the Zuni Indians for the purpose of working out the archæological and ethnological results of the Hemenway Expedition. A more extensive account of these phonographic studies of the Passamaquoddies will be published in the next number of the *Journal of American Folk-Lore.*—J. W. FEWKES.

PROCEEDINGS OF SCIENTIFIC SOCIETIES.

U. S. National Academy of Sciences.— The following papers were read at the meeting commencing April 15, 1890.

1. The effects of the inhalation of Nitrogen, Nitrous Oxide, Oxygen, and Carbonic Acid upon the Circulation: with special reference to the Nitrous Oxides, Anæsthesia and Asphyxia; H. C. Wood, presented by Dr. J. Billings. 2. On the Application of Interference Methods to Astronomical Measurements, A. A. Michelson. 3. Physiognomy of the American Tertiary Hemiptera, S. H. Scudder. 4. Totality of the Eclipse of 1889, December 22, D. P. Todd. Presented by the Home Secretary. 5. The Budding of Salpa considered in relation to the Question of the Inheritance of Acquired Characters, W. K. Brooks. 6. Recent Advances Towards a Knowledge of the Fishes of the Great Oceanic Depths, G. Brown Goode and Tarleton H. Bean. 7. A System of Classification of Variable Stars, S. C. Chandler. 8. On the Spectrum of Metals, H. A. Rowland. 9. On the Cheapest Light, S. P. Langley. 10. On the Relation of Secular Disintegration to certain Crystalline and Transitional Schists, R. Pumpelly. 11. On the Structure of the Green Mountains, R. Pumpelly. 12. The Interrelationships of the Ichthyopsida, Theo. Gill.

The following members were elected: George L. Goodale, Cambridge, Mass.; Russell H. Chittenden, New Haven, Conn.; Thos. L. Casey, Washington, D. C., and Richmond M. Smith, New York.

On the evening of Wednesday, April 16th, the Henry Draper Medal was presented to Prof. H. A. Rowland, of Baltimore, Md.

Prof. S. P. Langley resigned the office of Vice President, to take effect April 1, 1891.

Brookville, Indiana, Society of Natural History.—Annual meeting March 28th, Mr. E. R. Quick in the chair. The following officers were elected for the ensuing year:

President, C. W. McClure; Vice-President, E. R. Quick; Secretary, R. M. King; Corresponding Secretary, H. M. Stoops; Treasurer, A. W. Butler; Librarian, Edw. Hughes. Curators: Mammalogy, E. R. Quick; Botany, O. M. Meyncke; Ornithology, A. W. Butler; Entomology, C. W. McClure; Geology, C. F. Goodwin; Mineralogy, G. R. King; Archæology, H. M. Stoops; Icthyology and Herpetology, Joseph Fieber.

C. W. McClure presented a paper on "The Ox Worble," with especial reference to the damage it does by spoiling the hides of cattle in this vicinity. E. R. Quick read a paper on "Rats." He gave the date of the appearance of the common rat, as near as could be ascertained, in this vicinity, noted some of their habits, and gave special attention to the appearance of these animals within the past winter in unusual numbers at many points in the Ohio Valley. The following subjects were also presented by C. W. McClure, "The Early Blooming of Flowers," and "The Hibernation of Water Snakes (*Trop. sipedon*). By Edw. Hughes, "On the Occurrence of *Hyla pickeringii* and *Chorophilus triseriatus* in Franklin County, Indiana." By E. R. Quick, "Notes on the Breeding Habits of *Hyla versicolor*."

SCIENTIFIC NEWS.

Edmond Hébert.—Died April 4th, 1890, Edmond Hébert, Professor of Geology in the Sorbonne, Dean of the Scientific Faculty of Paris, and member of the Institute of France. Prof. Hébert was three times President of the Geological Society of France, and was the first President of the International Congress of Geologists. He was born at Villefargeau, near Auxerre, and his father was a soldier of the republic and of the empire. Hébert was the most accomplished stratigraphic geologist of France, and perhaps of Europe, especially in the Cænozoic and Mesozoic departments. He was the author of many important papers and memoirs. He was a man of much energy and also amiability of character, traits which were exhibited in his personal appearance and manners.

Sir Richard Owen was recently attacked by paralysis, a circumstance which gave rise to premature reports of his death. At last accounts he was slowly recovering, but at his advanced age his situation is regarded as serious.

During this the third season the Marine Biological Laboratory will have the following corps of instructors: Dr. C. O. Whitman, Director, Howard Ayers, H. C. Bumpus, E. G. Gardiner, J. S. Kingsley, J. Playfair McMurrich, W. M. Rankin, W. A. Setchell.

The laboratory is located on the coast at Wood's Holl, near the laboratories of the United States Fish Commission. It has added to it this year a library, a lecture-room, and six more private laboratories.

The building consists of two stories: the lower for students receiving instruction, the upper exclusively for investigators. The laboratory has aquaria supplied with running sea water, boats, collecting apparatus, and dredges; it will also be supplied with reagents, glassware, and a limited number of microtomes and microscopes. By the munificence of friends the library will be provided henceforth not only with the ordinary text-books and works of reference, but also with the more important journals of zoology and botany, some of them in complete series.

The laboratory for investigators will be open from June 2d to August 30th. It will be fully equipped with aquaria, glassware, reagents, etc., but microscopes and microtomes will not be provided. There are fourteen private laboratories supplied with aquaria, running water, etc., for the exclusive use of investigators who are invited to carry on their researches here free of charge. Those who are prepared to begin original work, but require supervision, special suggestions, criticism, or extended instruction in technique, may occupy tables in the general laboratory for investigators, paying for the privileges a fee of fifty dollars. The number of such tables is limited to ten. Applicants for them should state precisely what they have done in preparation for original work, and whether they can bring a complete outfit, viz.: microscope, microtome, camera-lucida, etc.

The laboratory for students will be opened on Wednesday, July 9th, for regular courses of seven weeks in Marine Zoology and Botany, and Microscopical Technique. It is desired that students owning microscopes or microtomes should bring them, and applicants for admission should state whether this requirement can be complied with. The fee for workers in this department is twenty-five dollars, payable in advance. The number of students will be limited to thirty, and preference will be given to teachers or others already qualified. By permission of the Director, students may begin their individual work as early as June 15th, without extra charge, but the regular courses of instruction will not begin before July 9th. In addition to the regular courses of instruction, consisting of lectures and laboratory work under the direct and constant supervision of the instructors, there will be two or more courses of lectures on special subjects by members of the staff. One such courses of six lectures will be given by Dr. McMurrich on the *Hydrozoa*. Similar courses on the *Crustacea* and *Echinoderms* will be given by Prof. Kingsley and Dr. Rankin. There will also be ten or more evening lectures on biological subjects of general interest. The first of these will be given by Dr. Whitman on July 9th.

Applications for places in either department should be addressed to Miss A. D. Phillips, Secretary, 23 Marlborough Street, Boston.

Rooms accommodating two persons may be obtained near the laboratory, at prices varying from $2.00 to $4.00 a week, and board from $4.50 to $6.00. By special arrangement, board will be supplied to members in the laboratory cottage at $5.50 a week. For information in regard to rooms, inquiries may be addressed, after May 1st, to Mr. H. C. Bumpus, M.B.L., Wood's Holl, Mass.